A Semi-Monthly Technical Newspaper

Metallurgical & Chemical Engineering

PUBLIC LIBRARY
JAN - 8 1917
WASHINGTON

New York, December 15, 1916 McGraw Publishing Co. Inc. Vol. XV, No. 12 25c a copy

COAL
THE ALBERT RAYMOND EXHAUST FAN CHICAGO
DUSTLESS
The Raymond System
PULVERIZING
AIR SEPARATIN
We guarantee results in the reduction o an enormous variety of materials to an desired grade of fineness, down to 20 mesh—or finer. Our system provides al the essentials necessary to highly-profit able operation. Investigate the many sided Raymond.
ECONOMICAL
Raymond Bros. Impact Pulverizer Co
1305 North Branch Street, Chicago, Ill.

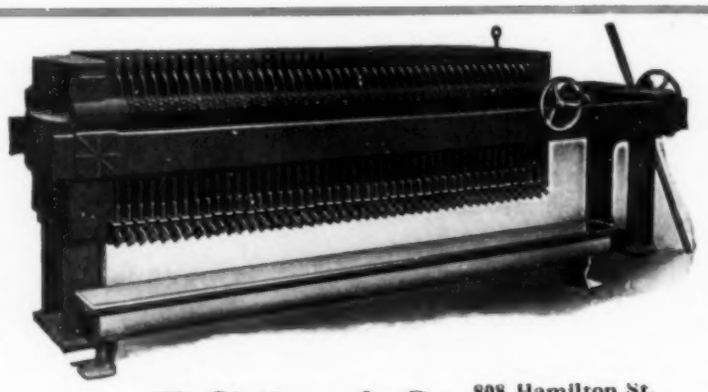
For Big Production and Low Operating Cost

SHRIVER FILTER PRESSES

They increase output and effect marked savings in filter cloth replacements and the recovery of values. Little attendance and less wash water adds to their economy.

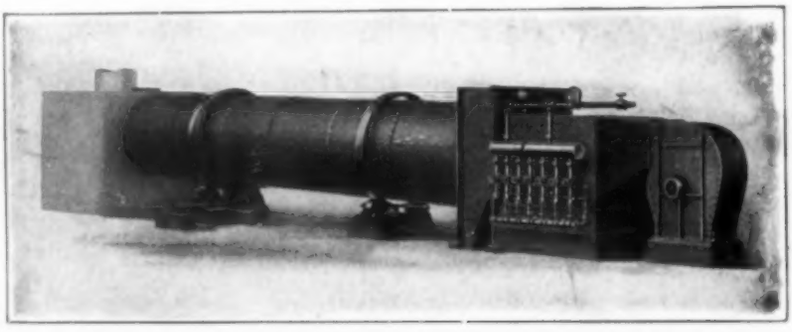
Have wide joint surfaces. Accurate finishing of plates and frames, coupled with an efficient tightening device, prevents leakage.

Presses for all industrial filtration. Small presses for laboratory work.



T. Shriver & Co. 808 Hamilton St. Harrison, N. J.

STEAM HEATED AIR DRYERS



for Drying Borax, Salts and other Chemicals.

Have equipped largest chemical plants in the world.

Also Direct Heat Dryers for By-Products.

American Process Co.
68 William St., New York

New neck and pods cast on to large roll with the aid of Thermit

Large connecting rod for 50 x 60" Galway Mill Engine repaired with Thermit

Thermit Welding Has Prevented Many Long Shut Downs in Steel Mills

The scarcity of spare parts and the frequent occurrence of break downs would have presented a serious problem to steel mills during the last few years if it had not been for the Thermit welding process.

There would have been a complete shut down in many of the Steel Mills because of the breaking of teeth in steel pinions, the breaking of connecting rods, slab mill spindle couplings, shear castings and many other sections.

Thermit welding for this class of work in normal times was considered a great saving in time and expense, but at the present time when mills have to work at high pressure Thermit welding has proved of inestimable value by quickly returning broken sections to service.

In the event of a break down, wire or telephone particulars to our nearest office and we will proceed to help you out of the difficulty at once.

Every mill Superintendent and Engineer who has not received our pamphlet, "Thermit Mill and Foundry Practice," should have a copy. It is known as pamphlet No. 1741.

Goldschmidt Thermit Co.

120 Broadway New York

329-333 Folsom Street, San Francisco
103 Richmond Street, W., Toronto, Can.
7300 So. Chicago Ave., Chicago, Ill.

Metallurgical and Chemical Engineering

A Consolidation of
ELECTROCHEMICAL AND METALLURGICAL INDUSTRY and IRON AND STEEL MAGAZINE

Vol. XV | NEW YORK, DECEMBER 15, 1916 | No. 12

PUBLISHED SEMI-MONTHLY ON THE FIRST AND FIFTEENTH OF EACH MONTH BY THE

McGRAW PUBLISHING COMPANY INC.

JAMES H. McGRAW, President.
A. E. CLIFFORD, Secretary. JOHN T. DEMOTT, Treasurer
239 West 39th St., New York.

TELEPHONE, 4700 BRYANT. CABLE ADDRESS, METCHAM, NEW YORK
ROCKY MOUNTAIN OFFICE.....401 Boston Bldg., Denver, Col.
PACIFIC COAST OFFICE.....Rialto Bldg., San Francisco, Cal.
CHICAGO OFFICE.....Old Colony Building
CLEVELAND OFFICE.....Leader-News Building
PHILADELPHIA OFFICE.....Real Estate Trust Building
LONDON OFFICE.....Hastings House, Norfolk St., Strand

E. F. ROEBER, PH.D., Editor.
S. FISCHER, PH.D., Western Editor.

J. MALCOLM MUIR, Manager.

Yearly subscription price for United States, Mexico and United States dependencies, $3.00; all other countries, $4.00.
Single Copy 25 Cents

When change of address is ordered, the NEW and the OLD address must be given. Notice must be received at least 10 days before the change takes place. No back copies for more than three months.

Copyright, 1916, by the McGraw Publishing Company Inc.

Entered as Second-Class Matter at the Post Office at New York, N. Y., under the Act of Congress, March 3, 1879.

Contents for December 15, 1916

EDITORIAL:
Supreme Court Decision in the Hyde Flotation Suit.... 665
Passing the Buck 665
Prices Up in the Air..... 666
The Steel Trade's Future..... 667

READERS VIEWS AND COMMENTS:
Guayule Rubber and Canaigre Tannin. By R. C. Canby. 668
Screen Efficiency. By Robert S. Lewis..... 668
Some Evidence Regarding Oxidation of Metals in Heating Furnaces. By Joseph Harrington..... 668
Belgian Kiddies, Ltd. 669
The Niagara Power Crisis..... 669
Coming Meetings and Events..... 671
Refractory Materials. (Symposium Before Faraday Society). 671
Program of New York Meeting of American Association for the Advancement of Science 676
The Electrolytic Oxidation of Sulfurous Acid. By M. DeKay Thompson and N. J. Thompson..... 677
The Selection of Centrifugal Pumps. By D. McEoceid..... 679
Rubber Sponge. By Andrew H. King..... 681
The Determination of Nickel in Iron Ores. By Philip Covitz.. 682
The Chemical and Physical Properties of Foundry Irons. By J. E. Johnson, Jr. 683
Grading in the Cement, Coal and Cork Industries. By Edward S. Wiard 685
Science and Industry. By J. Swinburne..... 687
The Thermal and Pressure Decomposition of Pentanes and Hexanes. By Gustav Egloff..... 692
The Utilization of Waste Heat for Steam-Generating Purposes. By Arthur D. Pratt..... 696
Manufacturing Commercial Salt Blocks by Hydraulic Pressure 708
A Machine for Testing Metal Sheets 709
Current News and Notes 710
PERSONAL 710
OBITUARY 711
BOOK REVIEWS 711
Market Reports—Iron and Steel Market Report, Non-Ferrous Metal Market and General Chemicals..... 711
Industrial—Financial and Construction News..... 714

Supreme Court Decision in Hyde Flotation Suit

The Supreme Court of the United States on Dec. 11 rendered the final decision in the suit of Minerals Separation versus James M. Hyde, reversing the Court of Appeals of the Ninth District at San Francisco and affirming the decision of the lower court at Butte, Mont., in favor of Minerals Separation. A record of the principal stages of this suit may be found in our Vol. XII, page 362, and Vol. XV, page 555. Since at the time of going to press the full text of the decision (which is stated to have been written by Judge Clarke and to have been unanimous) has not yet come to our hands, we must reserve further comment for our next issue. It is evident, however, that the Supreme Court has upheld the validity of the claims of patent 835,120 (owned by Minerals Separation) for less than 1 per cent of oil. And this is the fundamental point.

The Miami appeal to the U. S. Superior Court in Philadelphia from the Wilmington decision of Judge Bradford (our Vol. XIII, page 409, and Vol. XV, pages 433 and 441), is expected to be heard on Jan. 30, 1917. The flotation suits are, therefore, by no means at an end yet.

Passing the Buck

As was anticipated by students of the psychology of the Secretary of War, the temporary permit to generate more power at Niagara Falls was refused. To the representations of the Board of Directors of the American Electrochemical Society the Secretary of War replied by referring to a memorandum which appears in another column. The lengthy argument in favor of dodging the issue is apparently re-enforced in Mr. Baker's mind by a consideration that "the Falls themselves are one of the greatest, if not the greatest, natural wonders in the United States." Hence Mr. Baker argues that "under such doubtful powers" as he possesses he has not the power finally to set at rest the question of diversion. Evidently Mr. Baker thinks that a temporary permit to use about 1.5 per cent of "this mighty spectacle" would settle the question for ever.

It would be interesting to know why Mr. Baker's doubtful power was used to grant a temporary permit to use more water with the provision that the power generated from it should not be used in Niagara Falls.

Meanwhile the future is gloomy, for it is almost too much to expect Congress to settle the question in the very short session before it. If, however, it could find time to prop up the feeble arms of our doubting Secretary, so that the temporary permit could be granted, it would deserve the gratitude of the whole country.

Prices Up in the Air

We printed in our last issue a timely paper by G. O. Smith and C. E. Lesher of the U. S. Geological Survey on the cost of coal. It goes without saying that we have been doing very loose figuring in regard to this great source of wealth. We have been addicted to the glib but unconvincing theory that civilization may be measured by the quantity of coal destroyed, and we have been given to shallow rejoicing because the consumption in the United States for heating and lighting is as great as it is. By this statistical art we charge every papoose of the plains and sierras, and every picaninny of the alligator districts with 1 1/10 tons of coal, and by the same token we know that the rest of us use more. It does beat all, the kind of things we can really grow proud over, once we begin to expand our chests! We have not computed the average number of calories needed per person and compared this with the average B.t.u. available from 1 1/10 tons of coal in order to justify our boast of a red hot civilization that burns up so much. In certain of the countries now at war it is forbidden to burn coal for domestic use on the ground that the by-products which would thus be destroyed are needed for munitions. Householders must use coke; then the by-products are saved.

In the arts of peace these by-products are equally useful, and many things that are nowadays found useful in time of war will surely prove themselves worthy the attention of citizens in times of peace. Indeed, it is a fair guess that many varieties of profligate waste now practiced in this country will soon have the ill-repute they deserve.

In considering the costs of coal, Dr. Smith has brought out a factor which we have not considered heretofore as nearly so important as the facts seem to warrant. He calls this the "Resource Cost," and it has to do with the royalties paid to the lord, the patron or the owner of the land. This charge, he finds, runs up as high as $1 per ton of anthracite, taken from certain mines. The available anthracite being limited, the price of such coal lands has risen from $3 to $4 per acre to $3,000 of late years. The Girard College Trust gets, under its latest contract, about $1 per ton royalty on anthracite coal mined from certain lands which it owns. So long as anthracite is a necessity, and there is no more in sight, there does not seem to be any top to the royalties that may be enjoyed by the fortunate possessors of these lands.

This leads us into all sorts of economic difficulties. Let us suppose that we were The People of the State of Pennsylvania, and were called upon to solve the problem. Without doubt, the anthracite railways would assure us that if the right of eminent domain were given to them over all anthracite coal lands they would meet the situation with justice and efficiency. Somebody else might propose the Henry George Single Tax law, with a view to bringing the unused lands into the control of the State. Dr. Smith feels that the public control of coal lands is the solution of the problem. All of these proposals, except the most drastic one of Henry George and Herbert Spencer, involve taking from the owners of the coal lands the liberty to trade.

Now let us propose an economic theory right off the bat, and invite discussion. We postulate that all these palliative measures, such as State or federal control, etc., become necessary only when the public is not good enough or wise enough to meet simple situations. The selling public is not good enough if it imposes selling prices so high above costs as to cause an injury to the public, and the buying public is stupid if it pays the price. Most of us combine these two functions of selling our work and buying for our needs, so we are, nearly all of us, in the same boat.

Stupidity consists in large measure in the inability to shift from one angle of vision to another. If anthracite coal is too high and coke is cheaper, it is stupid not to use coke. If we are intelligent enough and have ginger enough we can make the shift; if we are not intelligent enough we cannot. It will be too difficult, too much trouble and, somehow, we shan't manage to get around to it. The man that has no time to take trouble has not the capacity to make anything but trouble.

It looks as though we had lost our kick and had become easy marks through shear inertia. A woman went out to buy a pair of shoes, and learned that, owing to the scarcity of leather, the price of shoes had advanced $2 a pair. With a view to economy, she asked for cloth shoes and was informed that the price of these was the same as those of leather. She then asked for low cloth shoes, and discovered that high or low, big or little, cloth or leather, the price of shoes was the same. What can be the matter with the customers of that store that the shoe-wallah can put over a game like that?

Little strips of sheet celluloid sold by apothecaries for tongue scrapers can hardly cost a cent. They retail for 10 cents each. In certain units of a chain of drug stores that display marvelous bargains in their show windows the price is 50 cents. "Celluloid is very expensive now," said the poor clerk. Poor man's coal in October was 25 cents a "basket," and in November the same amount costs 35 cents. The only explanation of that extra 10 cents is that the public will swallow any story as a reason for advancing prices. Apples are rotting on the ground in many places, but "everything is going up," and so the cost of apples to the consumer is soaring. Butter, eggs, and provisions are almost unprecedented in prices owing to the great scarcity, and yet the cold storage warehouses are stuffed to repletion with reserve supplies such as they have never carried before.

Now what are prices? They are what the owner of wares can get for them in exchange—what he can get purchasers to pay. If the purchaser is puny and weak, and has no resistance and lacks the strength to kick when too much is asked, and does not know when he is being overcharged, he will be asked too much every time. And he will have to pay. It looks as though the whole American public had lost the art of

buying, and if we have, all the socialistic laws that ever were thought of will not help us. We shall be anybody's meat.

The Steel Trade's Future

Is the steel trade facing an economic crisis? There has been a disposition in the present calendar year to cast such fears aside, because early this year a famous precedent was set aside. The trade had previously adhered to an idea that certain prices were "safe" and that the establishment of higher prices would lead somewhat quickly to a reaction, through consumption being curtailed. The highest steel prices between 1902 and 1916 were reached in 1907. A weighted average of finished steel prices, carefully kept for years, shows that at the end of 1915 the 1907 level had just been reached. Early this year steel prices transgressed that limit and yet buying was not curtailed. The steel companies have a much larger amount of business on books now than they had at the beginning of the year, and some of them suggest that they wish they had less.

The fact that the honored price limit has been exceeded without anything happening is no proof that conditions are safe. It is proof of nothing except that nothing has happened thus far. The advance in prices thus far this year is equal to double the advance that occurred last year. In other words prices have advanced, since the low point of December, 1914, three times as much as was required to bring them even with the top prices of 1907.

To cite the fact that steel prices have lately been advancing more rapidly than ever is, of course, no argument that there is no danger, but rather the contrary. According to the weighted average mentioned, the advances in the month of November were more than one-fourth the total advances that occurred in the preceding ten months. The curve of ascending prices is convex to the base line, suggesting that the line is soon to reach the impossible, when something must break.

Can the steel market yield merely to the extent of experiencing a period of stationary prices? Precedent is against such an assumption. In 1905 and 1906 steel prices rose, and remained stationary, through their own inherent strength, through the first ten months of 1907. They did not really break until more than a year later, but the support was artificial, with a great curtailment in production. That was the "Gary dinner" period, well remembered. In 1909 prices rose sharply, but they remained stationary at the top only for a few months, and the same statement can be made of the 1912 rise. Even in this present movement, the greatest of all, there has been something suggestive. There was a particularly rapid rise in prices during the first three months of this year, after which prices became relatively stationary, and quite promptly there arose fears that a break would occur before the end of the year. Possibly it was only because prices commenced a fresh and important advance last August that fears have been dismissed.

Now if the steel market feels safe as to its future only when prices are in the course of advancing it is really in a very unsafe position, for it is when prices are advancing that the position is being made less secure for the more distant future. Whatever goes up must come down, and the downward pull upon prices is not like the force of gravity, decreasing as the square of the distance, but more like the tension of a spring, increasing as it is distended.

Of the steel produced in the United States since the beginning of the war not more than 25 per cent has been exported, directly or indirectly. A continuance of the present demand requires therefore a continuance of the buying in the same proportions as hitherto, or, if buying in the one quarter is decreased buying in the other quarter must be increased correspondingly, and there must be at least a slight increase in the total to take care of the gradually increasing productive capacity. In the domestic market the ultimate buyer may be divided chiefly into two classes, the investor, who erects a bridge, an office building, a factory, or something of that sort, and the common people, who buy tin cans with food, paint, etc., inside, magazines with wire stitching, tools, stoves, and indeed a very wide range of things. Now the investment buyer is, on the whole, far from active. Reports of the Bridge Builders' and Structural Society show that in August, September and October the structural steel lettings were less than 65 per cent of the fabricating capacity. As to the common people, the high cost of living is forcing them to economize, whereby they buy less quantity than formerly even though they spend more money. With the steel industry it is purely a question of quantity. It is the tonnage that must be sold.

There is a theory prevalent just now that if the American people find themselves unable to continue in future to buy three-fourths of the steel we produce the foreigners will buy whatever is left for them. Assuming that the proportions have been 75 per cent and 25 per cent, then if domestic buying is reduced one-third export buying must be doubled, to maintain the total 100 per cent, disregarding the fact that productive capacity is increasing. For exports to double would be a sensational development. Our merchandise export trade in general is enormous only as to its value, not as to its quantity. The world's merchant shipping is less than before the war started, and the quantity of goods exported cannot be much if any greater than formerly. The tonnage of steel exported is, however, about double the quantity exported in 1912 or 1913, so that it is already large in quantity as well as in value. It is true that at the present time export prices for steel are higher than domestic prices, but it does not follow that the foreigners would continue to bid the higher prices if they were offered a materially increased quantity of steel.

Readers' Views and Comments

Guayule Rubber and Canaigre Tannin

To the Editor of Metallurgical & Chemical Engineering

SIR:—The article on the guayule rubber industry in your issue of Nov. 15 and the editorial on the same were interesting and timely.

I happened to be upon a professional visit at Mapimi, Mexico, at the time guayule was being gathered in that vicinity. During the first two weeks of my visit the Penoles company's railroad was crowded to capacity in handling the shipments. But soon the territory tributary to this road was completely exhausted.

The result of attempts to grow the guayule plant and finding a lack of gum in the cultivated plant is paralleled by the experience previously found in attempts to grow canaigre root for tannic acid. The natural desert growth contained a high percentage of tannin. But while the plant grew luxuriantly under irrigation cultivation, the cultivated plant contained so little tannin as to be practically worthless.

Unfortunately a tannin works with large copper stills was built near Dening, N. M., while the cultivated crop was being grown. The works stood idle for many years and were finally dismantled.

R. C. CANBY.

Wallingford, Conn.

Screen Efficiency

To the Editor of Metallurgical & Chemical Engineering

SIR:—On page 320 of the issue of METALLURGICAL & CHEMICAL ENGINEERING for Sept. 15, 1916, the following method of calculating the efficiency of a screen is given:

Efficiency =

Weight of undersize passing through screen

Total weight of undersize in feed to screen.

For some years I have made use of the familiar formula for calculating extractions in connection with mill work, which involves only assays or percentages, no weights being necessary.

$$E = \frac{c\,(a - b)}{a\,(c - b)}$$

where

a = assay of heads.
b = assay of tails.
c = assay of concentrate.
E = extraction, as a decimal.

In order to illustrate the application of this formula to screens, the following screen analyses are given:

CUMULATIVE PERCENTAGES ON THE VARIOUS SIZES

Mesh	Feed	Undersize	Oversize
+20	11.8%	1.2	55.9
30	28.8	12.7	81.0
40	39.4	24.4	87.8
80	62.8	49.3	92.4
200	83.4	73.9	95.6
—200	100.0	100.0	100.0

These are the results of screen analyses of the feed, undersize and oversize, where the material was fed to a 30-mesh screen.

Where fine screening is being done, it is important to know the efficiency of the screen on the small sizes. If much of the fine material goes into the oversize, it would indicate that the screen was being overloaded, or else an insufficient quantity of wash water was being used.

Assume that it is desired to calculate the efficiency of the 30-mesh screen on 80-mesh material. Then

a = per cent through 80-mesh in feed.
b = per cent through 80-mesh in oversize.
c = per cent through 80-mesh in undersize.

Subtracting the cumulative percentages on 80-mesh from 100 to get the percentages through 80-mesh and substituting in the formula:

$$E = \frac{50.7\,(37.2 - 7.6)}{37.2\,(50.7 - 7.6)} = .936 = 93.6 \text{ per cent efficiency.}$$

In the example given in the article referred to, the data was for a 1.5-mm. screen.

Size	Feed	Oversize
Over 1.5 mm.	80.1%	87.5%
Under 1.5 mm.	19.9	12.5
	100.0	100.0

The percentages through 1.5 mm. for the feed and oversize are 19.9 and 12.5 respectively. In order to apply the formula the percentage of undersize through 1.5 mm. must be known. As no figures are given for the undersize, it is assumed that this figure is 100 per cent.

$$\text{Then } E = \frac{100\,(19.9 - 12.5)}{19.9\,(100 - 12.5)} = 0.427 = 42.7 \text{ per cent}$$

as against 42.51 per cent by the first method.

The discrepancy of 0.2 per cent might be due to some of the oversize going into the undersize. Elongated particles might pass the screen during a test and yet be caught on the same size opening when the screen analyses were made. In any case, the checking by the two methods is far closer than the inaccuracies of screen testing would lead one to expect.

ROBERT S. LEWIS,
Associate Professor of Mining.

University of Utah,
Salt Lake City, Utah.

Some Evidence Regarding Oxidation of Metals in Heating Furnaces

To the Editor of Metallurgical & Chemical Engineering

SIR:—An analysis of the flue gases emerging from a billet-heating furnace when fired with fuel oil as compared to the analysis of the gases from the same furnace in firing with powdered coal affords interesting data on which to base a theory in regard to the destruction of metal by oxidation within the furnace. In a number of instances wherein I have made a series of gas analyses in both cases I have found that with fuel oil, when operating under what were considered by the heater to be good furnace conditions, the flue gases analyzed from 8 to 11 per cent of CO_2.

Under these conditions the scaling of the billets was very noticeable, there being approximately five sixty-fourths of an inch of scale, this being the average of a number of measurements taken from various parts of the bar. When the bar is pulled out of the furnace door and allowed to drop onto the floor plates a very noticeable deposit of scale is produced. It falls off of the bar in large flakes or scales, which are of sufficient thickness and strength to maintain their form and permit of free handling in pieces up to 5 and 6 in. long. The scale in this instance is shiny and smooth on the outside and has a pitted, rough interior. A cross-section shows the structure quite clearly, the external half being very dense and compact, and showing that the oxide is solid and continuous. The interior half of the scale is inclined to be spongy and porous, and on the surface has a deeply pitted aspect.

This being a method of firing which has been in service for some years, statistics are available in regard to the actual percentage of scale loss. This runs according to the character of the steel and the amount of original rust, from 4 to 6 per cent by weight.

Observe now the scale produced from exactly the same billets in exactly the same furnace, but fired with pulverized coal as a fuel. The change from oil to coal was accomplished over night, and the same crew was in charge of the operations, and the billets came from the same pile in the yard. I feel, therefore, that there was no change in the conditions other than the fuel, so that any effect on the scale could be directly attributed to this. Perhaps the fact that the billets heated more rapidly had something to do with it, but it was quite noticeable that the amount of scale dropping off the billet when it hit the floor was less in the case of powdered coal than with fuel oil. Analyses of the flue gas with coal showed a practically constant quantity, there being between 15 and 16 per cent of CO_2. Inasmuch as Indiana coal was being used, the sum of the CO_2 and oxygen was about 19 per cent. The average amount of free oxygen in the flue gases was therefore between 3 and 4 per cent.

This particular furnace has not been operated as yet a sufficient length of time to get a line on the percentage of scale loss. This is a figure which it is difficult to get accurately except by using the figures derived from several months' operation.

It was difficult to get a piece of scale from the coal-fired furnace large enough to use as a sample, because it was so thin that it was exceedingly fragile. The lessened amount of scale was, however, so noticeable as to be commented upon by the mill men. Further and more accurate data will be developed before very long, in connection with a continuous rail-heating furnace which I am now equipping with powdered coal.

The value of this evidence can scarcely be overestimated, there being more economy derivable from this than from the fuel saving itself. The normal capacity of such a furnace as I have in mind is about 200,000 lb. per day. Assuming that there is a scale reduction of 2 per cent, there would follow a direct increase in the amount of steel produced of two tons per day. Assuming again that the differential between scale and steel is $40 per ton, there will follow a daily saving of $80 or an annual saving of $24,000.

Inasmuch as the entire equipment for producing and supplying pulverized coal to such a furnace is well within this figure a saving of considerable magnitude is apparent. In theory, at least, the oxidation of steel should be in proportion to the amount of oxygen present in the furnace. I am hoping that my contention will be borne out in practice that metals can be heated up to at least 2000 deg. in a neutral furnace without any oxidation whatsoever. This is accomplished in such cases as sheet and pair furnaces with hand-firing, but is only done at a considerable cost in efficiency loss due to the method of firing. I have hopes that the day is coming when steel can be heated to a rolling temperature without any loss whatsoever from oxidation.

Chicago, Ill. JOSEPH HARRINGTON.

Belgian Kiddies, Ltd.

An informal committee of American Mining Engineers is sending out an appeal to mining engineers throughout the United States, reading in part as follows:

"An informal committee of Mining Engineers, from all over the United States, are undertaking to give our friend Herbert C. Hoover a Christmas present, by taking off his shoulders part of the burden which he and his associates have been carrying for the last two years and a half.

"During this time, the United States has received a great deal of gratitude from Belgian people which it has not deserved. To the Commission for Relief in Belgium all praise is due for its work. The C. R. B.—as it is known—has distributed in Belgium goods costing about $227,000,000, of which the United States has contributed $10,000,000 or about 4.3 per cent of the total; and much of this has come from a few large foundations.

"This is naturally discouraging to us who know and appreciate the work of American Engineers in Belgium. These men have been keeping alive a population of nine million on one meal a day. This is not enough for children. (Would you like it for yours?) At present one million children are failing in health, and the C. R. B. has asked us Americans to assume the proper feeding of these children as our little share of the big job.

"To do this right the C. R. B. has started to give the children a nourishing noon-day meal, and it has not the money to carry it on. This costs only $1 per month per child (three cents a day). This seems incredible but as the overhead expenses of the C. R. B. are only ¾ of 1 per cent of the gross cost you will understand that this is real engineering efficiency.

"As Engineers we want to show our appreciation and so we have organized an informal syndicate to float a new venture. We would like to cable Hoover before Christmas that we will take a block of 'Belgian Kiddies' off his hands."

The program is to float 10,000 shares of a demand value of $12 each. "Each share sold means 365 square meals for one child."

The appeal is signed by W. H. Bassett, F. Bradshaw, D. W. Brunton, D. H. Browne, R. B. Carnahan, Jr., R. M. Catlin, A. C. Clark, J. P. Channing, F. H. Clymer, J. V. N. Dorr, W. Douglas, H. S. Drinker, T. C. Dupont, S. A. Easton, C. W. Goodale, J. C. Greenway, H. G. Hixon, C. B. Hollis, R. J. Holden, R. W. Hunt, G. P. Hulst, H. Jennings, D. C. Jackling, W. R. Ingalls, W. Kelly, E. B. Kirby, C. B. Lakenan, D. A. Lyon, J. F. McCarthy, C. H. MacDowell, G. Macfarlane, J. MacNaughton, E. P. Mathewson, C. G. Memminger, C. W. Merrill, C. E. Mills, P. N. Moore, S. W. Mudd, R. V. Norris, H. C. Parmelee, C. F. Rand, F. B. Richards, R. H. Richards, L. D. Ricketts, M. Roberts, J. C. Ralston, D. M. Riordan, T. Robins, T. A. Rickard, W. L. Saunders, E. A. C. Smith, F. M. Smith, J. M. Sully, T. B. Stearns, C. R. Van Hise, W. R. Webster, H. V. Winchell, C. W. Whitley, I. C. White, P. Yeatman.

Subscriptions are to be addressed to Belgian Kiddies, Ltd., Room 2124, 120 Broadway, New York City. It is hoped that the entire sum will be subscribed for before Christmas.

The Niagara Power Crisis

The final outcome of the power crisis at Niagara Falls is now in the hands of Congress, the Secretary of War having skilfully side-stepped the issue. His reply to the letter addressed to him by the order of the Board of Directors of the American Electrochemical Society and reported in our issue of Dec. 1 (page 617) consisted of a reference to the following memorandum:

War Department,
Washington.

Oct. 31, 1916.

Memorandum decision of the Secretary of War:

I have before me certain papers with regard to a proposed additional diversion of water from the Niagara River. These papers comprise an elaborate report to the Chief of Engineers, through the division engineer of the Lakes Divi-

sion, setting forth in detail the present power development and use on both sides of the Niagara River, and lead to a recommendation that a temporary permit be granted to the Niagara Falls Power Company for a total diversion of 10,000 cubic feet per second, with a proviso that the additional power developed be sold to the Buffalo General Electric Company, and that a temporary permit be granted to the Hydraulic Power Company for a total diversion of 8785 cubic feet per second, with certain limitations upon the use and distribution of the additional power generated, that these permits may be limited in time and be subject to cancellation at any time by the Secretary of War. The Chief of Engineers has carefully examined these recommendations, and in the main concurs in them, so that the question before me is upon the issuance of such temporary permits.

At the outset I should express my approval of the thoroughness with which this investigation has been made and the wise and adequate safeguards recommended by the Chief of Engineers upon the action proposed to be taken.

But the question presented is one of very great importance and one having a history, and I must determine, first, whether I have any legal authority to issue the permits proposed, and, second, if I had such authority, whether it is sound administrative policy for me so to do.

The diversion of water at Niagara Falls for the generation of power began in 1892, at which time there was no international agreement between Canada and the United States on that subject and no legislation of Congress attempting to regulate such diversion. Since that time various legislative enactments and one treaty affecting the subject have been enacted. Chronologically considered, the legislative enactments are the two general dam acts and the so-called Burton Act. The treaty is, of course, the International Agreement between Canada and the United States fixing a limit of 20,000 cubic feet seconds as the total amount of water which may be diverted on the American side. The policy of Congress as at present expressed denies to the Secretary of War the right to authorize the diversion of water from international boundary streams until after Congress shall have first in individual and particular cases so determined. The provision of the present General Dam Law (Act of 1906, amended by the Act of 1910) in terms deal with streams in which water is to be accumulated by the construction of dams prior to its diversion. To this extent, therefore, the Act is not applicable to the Niagara River, since no dam has been, or needs to be, constructed there. It might be possible to assume either that the Congress regarded the difference in water level at Niagara as a natural dam, or that the General Dam Law wholly omitted Niagara Falls and intended to leave that stream the subject of special legislation because of the obvious special features affecting its treatment. The latter view seems the more reasonable, in view of the fact that the so-called Burton Act passed in 1906 did deal expressly with the situation at Niagara Falls. This Act limited the amount of water which could be diverted under permits issued by the War Department to 15,600 cubic feet seconds. At the time of its passage, the Burton Act was regarded as a temporary expedient recognizing the existence of certain occupants of this water power by limiting the total diversion, and the Act was itself limited to expire by its own terms. Congress from time to time reconsidered the subject and extended the date of expiration of the Burton Act, but at no time authorized a diversion in excess of that contained in the original law. On March 4, 1913, the Burton Act as extended expired by limitation, leaving no law in force either giving authority to the War Department or in any other way affecting the diversion of water at this point. In the meantime, shortly after the passage of the original Burton Act, the International Agreement was made, by which the United States was authorized to sanction diversions up to the amount of 20,000 cubic feet seconds, but this treaty gives the War Department no power, and Congress has not legislated under the treaty to give to the Secretary of War or to any other Governmental agency the right to regulate these diversions within the treaty allowance. If, therefore, the Secretary of War has any legal authority in this matter, it must proceed from the provisions of the General Dam Act, and that by an uncertain, if not a strange, construction.

It might be said that the Secretary of War, acting with the Chief of Engineers, has power, under Section 10 of the Act of March 3, 1899, but in view of the fact that the legislation of Congress with regard to the diversion of water for power purposes has always been, or has in recent years been, entirely separated from its treatment of the diversion of water for the purpose of changing the course of streams, this suggestion lends but doubtful assistance in the effort to seek departmental authority for the proposed permits. The net effect, therefore, is that the authority of the Department in the premises is doubtful.

For many years pressure has been brought to bear both upon Congress and this Department for permission to increase the diversion of water at Niagara Falls. Great commercial and industrial interests have developed at the site of this spectacular water power. The falls themselves are one of the greatest, if not the greatest, natural wonders in the United States; the power there is concededly the greatest water power in our country. There has been a conflict of feeling in the country as to whether commercial and industrial uses should be favored or rigid regulation imposed upon them in the interest of the preservation of this mighty spectacle. It may be that this division of feeling is responsible for the Congress having failed as yet to establish finally a policy, and this Department, under such doubtful powers as are above set forth, has not the power finally to set the question at rest. The most that could be done by the Department in the issuance of temporary permits of the character proposed would be to complicate the problem of ever finally settling a policy for, if these permits should be granted, engagements would inevitably be entered into by the enterprises using this additional power, commercial and industrial expectations would be created, and when Congress came to consider the whole question, it would find itself embarrassed by the fact that this Department had allowed industrial and commercial ventures to expand and make investments and contracts, which, while giving them no lawful claim, would create equities in their behalf prejudical to what might otherwise be deemed the general public interest in treating the question. As I have said, efforts have been constantly made in recent years to secure authority for increased diversions. The representations now made do not differ in character from those made aforetime. The difference lies wholly in the fact that we are in a period of quite unusual industrial activity and the expansion of the industries located at Niagara Falls seems to those interested in them to be associated with the general question of the country's industrial activity and therefore to present what is termed an emergency requiring immediate relief. Congress will meet in December. It will undoubtedly have before it the whole question of the treatment of water power and many of its members have for years been acquainted with the situation at Niagara Falls. The solution of the problem presented by the diversion of water there can be brought to the attention of the legislative body whose proper function it is to consider both the private and public interests involved, and I cannot consent to take advantage of a doubtful power for the purpose of temporary relief in industrial and commercial matters, and at the same time complicate the problem which the Congress must consider and leave that body less free to solve finally this most important question. I cannot, therefore, issue the temporary permits recommended and request the Chief of Engineers to notify those interested in such permits that their relief lies with Congress and that this Department will limit its action to the execution of such laws and policies which Congress establishes on the subject.

NEWTON D. BAKER,
Secretary of War.

The Secretary of War having refused to take action himself has, according to the news from Washington, recommended that temporary permits should be given to generate more power and has also advised Congress that in considering its legislation as regards further diversion it should keep in mind the preservation of the Falls by actually diverting more water. This is recognized as very interesting, but hardly a solution of the present crisis since legislative action by Congress during the present session seems highly improbable.

Meanwhile, the Canadian Government has not yet made the threatened prohibition of export of power. There has been a meeting at Ottawa attended by representatives of the power companies and there will no doubt be some action in the matter before long.

It is believed that the Canadian Government officials are really anxious to avoid causing inconveniences and loss to the United States manufacturers, but while desiring to be perfectly just they cannot let their own people suffer for a lack of power to which they are entitled. Therefore eventually export of power to the United States from Canada will be stopped unless there is an extraordinary check to industrial activity. This is not expected, but rather that the demands of Canada for power will increase much more rapidly than our Congress can legislate.

Coming Meetings and Events

American Association for the Advancement of Science meets with American Chemical Society, American Electrochemical Society and the four engineering societies at the Engineering Societies Building, New York, Christmas week, 1916.

American Institute of Chemical Engineers, New York, Jan. 10-13, 1917.

Society of Chemical Industry, New York Section, Perkin Medal Award, New York, Jan. 19, 1917.

Refractory Materials

Symposium Before Faraday Society

The Eighteenth Ordinary Meeting of the Faraday Society was held on Wednesday, Nov. 8, 1916, at the Institution of Electrical Engineers, Victoria Embankment, London, W.C., when a general discussion was held on refractory materials.

The president, **Sir Robert Hadfield**, was in the chair, and he opened the proceedings with an introductory address.

In spite of the vital importance of refractories to many national industries, the subject has received little attention in this country during the last few years, and in many instances the industry had not the scientific foundation required for its healthy development. That was the justification for the present symposium, out of which it was hoped improved practice would spring. The chief sources of refractories were probably silica, chrome clay, magnesite, dolomite, chromite, bauxite, graphite, and zirconite. The president next touched on the question of the properties of refractories, and he gave an abstract of the "Standard Specifications for Refractory Materials" published by a joint committee of the Institution of Gas Engineers and the Society of British Gas Industries in 1912. In 1908 Mr. F. J. Bywater had read an important paper on this subject before the former institution, and this was being reprinted in connection with the present meeting. An interesting résumé was given here as to the origin of fireclays, and it was shown how difficult it was to establish a relation between their fusibilities and compositions based merely on ultimate analysis. "Mechanical" analysis was first necessary, and the material divided up into kaolin, or true clay substance, quartz, and felspar. Of these the first, $Al_2O_3 \cdot 2SiO_2$, is the most infusible. The amount of accompanying fluxes, iron oxides, lime, magnesia, potash, and soda—which flux in the ratio of their equivalent combining weights—is, however, a very important factor.

The address next dealt with the classes of refractories in use, namely, acid, basic, and neutral, and the special properties and use of each were indicated. The comparatively new refractory zirconite was discussed in somewhat fuller detail. A series of exhibits illustrated some differences in practice between good and bad refractories. Thus the diameter of a magnesite nozzle remained quite unaltered at 1 in. even after 28 tons of steel had been poured through it, whereas that of an ordinary fire-clay nozzle increased to 2 in. The difference might well represent slag embedded in the steel.

Some photomicrographs were shown, illustrating the use of microscopy in the study of refractories, and the address concluded with a bibliography of papers and books and with a series of tables giving complete analyses, largely compiled from the author's own records, of most of the refractories in common use.

The opening paper of the symposium was given by Dr. **J. W. Mellor** (Stoke-on-Trent), and it dealt with "The Texture of Firebricks."

What constitutes a good firebrick is a favorite question, and one which does not admit of a satisfactory answer. The requirements from firebricks vary so widely in different furnaces, or in particular parts of a single furnace, that the ideal firebrick can be defined only in abstract terms, and this the more because some properties can be highly accentuated only at the expense of others.

Texture is one of the most important qualities of a firebrick, since, assuming that the chemical composition and refractoriness are otherwise satisfactory, the life and character of the firebrick are largely determined by its texture. The texture of a refractory may vary from that of the light porous bodies used in making bricks for insulating boilers, etc., to non-porous or vitreous bodies used in making crucibles, acid-resisting bricks for acid towers, etc. There are quite a number of intermediate types. The different types of texture were exhibited. The samples were prepared by cutting the brick transversely, polishing an exposed face, and finally cementing a glass plate on the polished faces by means of hot Canada balsam.

It was shown that the refractoriness of a firebrick under ordinary conditions of measurement is dependent to a small extent on the grain-size. The after-contraction of firebricks and the after-expansion of silica bricks is due to the arresting of the changes which occur during the firing of a brick before they are completed.

For bricks which have to resist the abrasive action of streams of flue dust, coal ashes, slags, etc., a close texture is necessary; but a close-textured brick is liable to split with abrupt variations of temperature. To reduce the tendency to splitting in this way, a uniform texture is desirable. The chemical composition of the brick in relation to that of the dust and slag it has to resist at high temperatures is of great importance. Examples illustrating the importance of both texture and chemical composition were shown. In slags which exert a severe action on the firebrick, the importance of small well-fitting joints, cemented by a good jointing clay, was also emphasized, since with bricks having a close uniform texture and the right chemical composition the joints are the weakest places.

Other examples were also given, showing that the texture of a firebrick is as important as chemical composition and refractoriness. The texture is a property which can be largely controlled by the manufacturer, whereas the other qualities are not so amenable to treatment. It was shown, by using the blast furnace as an illustrative example, that the consumer must carefully consider the conditions which prevail in different parts of any particular furnace before he selects for trial particular types of texture as likely to suit particular parts of his furnace.

Professor **W. G. Fearnsides** (Sheffield) spoke principally on "The Application of Petrographic Methods to the Study of Refractory Materials."

By way of introduction Professor Fearnsides called attention to the circumstance that, though there is a woeful lack of scientific data to help makers of refractory materials who are starting a new line to command certain success in any one of the manufacturing processes involved in the making of a brick, there is among the foremen brickmakers and furnacemen a great deal of information which only needs to be collected, codified, and interpreted to make it as scientific as the best laboratory product. One of the most pressing necessities in refractory material manufacture at the present time is for scientific workers to go through the works and listen when practical men bring

out information in terms which are the language of the brickyard or the foundry, and which they should translate and express in the international language of time and inversion-temperatures of grain-sizes and chemical compositions which are the usual currency of those superior people, who think they know. A great deal might also be accomplished if actual makers who have obtained a measure of success and users who are subjecting the material manufactured to unusual stress would work together and face awhile each the other's difficulties; and if, alongside, there might be a competent and sympathetic man of science who would stand by and hold the balance and occasionally give his help to spoke a wheel, the progress of the refractory-making industry would be more rapid than many people think. Though in its best developments the art of making refractory materials is in advance of the science, the practice of the art, by unskilled makers, leaves much to be desired, and it is certain that out of a scientific study of the craftsman's methods would come experience, in the light of which repetitive practice might, with advantage, be scientifically controlled.

Referring to the application of the microscope to the study of refractory materials, Professor Fearnsides recalled the pioneer work done by the late Henry Clifton Sorby, of Sheffield, who some fifty years ago, in the course of his early work on the physical constitution, first of rocks and afterwards of metals, rubbed down preparations both from silica bricks and firebricks to a condition of fair transparency. In determining the texture of any brick the thin slice method is one of direct and easy application. In the study of the relationship between the plums and the porridge which together make up a brick, great skill of manipulation is required to bring the method to any great success. Attainment of a technique which will make evident the character of the "binder" has offered greater difficulties than either the slicing of rocks or the preparation of polished and etched surfaces of almost any metal. These difficulties, however, should not be insuperable, and in a brick made from basic materials in which high refractive-index is a characteristic property (e.g. magnesia, chromite, shrunk-bauxite, zirconia, and the like), one knows enough already to judge at a glance the measure of success which the brick manufacturer has attained, and with experience to guide one it is not difficult to foretell approximately how particular batches of bricks will behave in the furnace. With new-made silica bricks, and especially with firebricks, the determination both of the composition and of the intrinsic structure is not so easy, and with slices of normal thinness (between 1/500 and 1/1000 of an inch), new formed materials are in such tiny crystals that they generally interfere one with another and appear as a felted mass. Characteristic inversions of quartz to tridymite and crystoballite in silica bricks are comparatively easy to observe, and from structures revealed by the petrographical microscope one can determine with fair accuracy the heat treatment which a silica brick has received. More satisfactory, however, from the point of view of demonstration specimens, are micro-preparations cut from the bricks turned out from the linings of large furnaces when those furnaces are dismantled at the termination of their run; and probably it is by careful selection and the scientific study of the more successful of these highly metamorphosed end products that scientific workers will first gain information which may suggest a probable direction for the manufacturer's next advance.

At this point the president asked Dr. **R. Lessing** to show a series of specimens illustrating a method of testing he had devised five or six years ago for ascertaining the texture and rational composition of refractory mixtures before firing.

The method consists of a simple process of elutriation, by which the true clay substance of the "green" clay is removed by a gentle current of water and separated from the water by allowing it to settle out on standing. The rate of flow of water is so adjusted that the "grog," i.e. the previously fired portion of coarse particles which eventually forms the rigid skeleton of the firebrick, and also the heavy and coarse grain residue of the "green" clay, consisting of sand, shale, or carbonaceous substances, are left behind in the elutriating vessel.

Elutriation is continued until the last clouds of clay substance are removed and the water becomes perfectly clear, with the lightest portions of the residue floating just below the outlet.

A very simple form of elutriator, accurate enough for works purposes, consists of a tall glass cylinder into which the water is passed through a glass tube reaching nearly to the bottom. The cylinder is placed in a bucket, into which the clay suspension overflows, and to which the clear water is syphoned off after settling. For the purpose of the test about 500 grams of the sample (which may be taken before or after "tempering" or from a molded body before or after drying) are well soaked in water and washed into the cylinder. The resultant products of clay and residue are dried, and a grading test is then performed on the residue, from which the texture of the body and the ratio of grog, granular clay, shale, and coal can be ascertained.

The specimen exhibited showed that before the standard specification was adopted mixtures for gas retorts contained very little grog, which had, moreover, suffered largely from excessive crushing, yielding dust, whilst the "green" clay serving as binder had largely remained in the form of coarse granules instead of being reduced to fine powder. The change in manufacturing methods by which the "grog" is crushed and graded separately and the powdered "green" clay mixed with it were shown by specimens taken after the adoption of the standard specification. For comparison a sample of a German retort mixture was shown, which was remarkable for its large proportion and size of grog, viz. 66 per cent, as against 35 per cent in English retorts, and also for the total absence of clay residue, shale, or coal, indicating that the binding clay had undergone some preliminary purification.

The test has been used successfully for the daily control of manufacturing operations, and is recommended by the author for this purpose, and in the absence of a reliable quantitative method for ascertaining the texture and rational composition of refractories is a simple and useful guide.

Dr. **H. G. Colman** gave a short account of the work on Refractory Materials carried out by the joint committee appointed on the subject by the Institution of Gas Engineers and the Society of British Gas Industries.

This committee, consisting of representatives of both the users and manufacturers of refractory goods for gasworks purposes had, after determination of the conditions prevailing in gas-retort settings under present day conditions, drawn up provisional specifications relating to the different classes of fire-resisting goods commonly in use in gasworks, namely, retort material, ordinary firebricks and silica bricks, prescribing, among other more general matters, the physical tests with which these goods must comply. In addition, the

committee were carrying out investigations on matters likely to be of value to both users and manufacturers and to assist in the provision of the fire-resisting materials most suitable for the above purposes; the means at their disposal, however, had not enabled them as yet to make more than a commencement of the work in this respect, investigations being now in progress on points such as the effect of pressure on the refractoriness of materials, the relative effects of an oxidizing and reducing atmosphere, and the influence of the fine flue dust carried into the hot setting on the life of the materials employed.

Mr. **J. Allen Howe** made a statement on the "Recent Work of the Geological Survey on Refractory Materials."

The statement indicated what the survey has done since the war in preparation for the forthcoming report on British Refractory Materials. The country has been blocked out into field-areas, and from each samples of raw materials have been secured and classified, the geological character of their locality and the nature of the deposits having been exactly noted. In each main center both producers and users of refractory materials have been consulted. The main groups of material may be classified as the silica group, the fire-clay group, refractory sands, and dolomite, and the report will probably be issued in corresponding sections. Well over 1500 samples have so far been received, and the collection of the raw material—the first stage of the work—is almost completed. The next stage, putting into shape the field-notes and the chemical, petrological, mineralogical, and textural examination of the specimens, is already well advanced. Arrangements are being made to test the refractoriness and determine other physical characteristics of the materials, and the data so obtained will be included in the report.

Dr. **A. Strahan,** director of the Geological Survey, supplemented Mr. Howe's statement. After a reference to the practical value of the 6-in. survey maps, he emphasized that the report will tell manufacturers exactly the extent and nature of the reserves of refractory minerals in this country, and specimens for examination will be available in the museums. A selection from the samples collected was exhibited at the meeting.

Mr. **T. Crook**, of the Imperial Institute, in commenting upon the specimens exhibited by Dr. Wyndham Dunstan, director of the Institute, stated that Great Britain was well provided with resources in the less common refractories, such as graphite, in India and Canada; chromite, which is abundant in Rhodesia and India; magnesite in Victoria, South Africa, and British Columbia; bauxite in India and British Guiana, and zircon in Natal.

Mr. **Cosmo Johns** (Sheffield) dealt with the "Use of Silica as a Refractory Material in Steel Manufacture."

After briefly referring to the use of refractory sands and the advantage of small amounts of impurity, the status of the silica or Dinas brick was discussed. He pointed out that owing to the fact that the raw material of the industry was never pure, the brick itself was a mineral aggregate of extreme complexity, and owing to the absence of exact knowledge as to its thermal history, it could not be treated from the simple standpoint of the binary system lime-silica. Its constitution at high temperature could not be predicted from a petrological study of the brick before or after use in our present state of knowledge. The important changes it undergoes during long service under furnace conditions, with the accompanying absorption of magnetic oxide of iron were mentioned, and it was suggested that though the magnetite was possibly only an indicator signifying the nearer approach to equilibrium of the original components at the high temperatures the brick had been subjected to for a long period, the possibility that the magnetite was not a passive agent was not excluded. It was suggested that the lines along which investigations might be made with the prospect of early and useful results would be the study of the effect of texture by varying the grain-size and correlating texture with such physical properties as refractoriness and ability to withstand variations of temperature. When the most suitable texture had been decided upon, the investigation of the time-temperature curve during burning of the brick could be undertaken.

Mr. **Albert Cliff** (Stamford) spoke "On the Manufacture of Refractory Materials," putting forward in a general way the makers' point of view.

Various suggestions were made as to the directions in which improvements in manufacture were possible. One was in the reworking up of old material; this would be one of the best means of eliminating expansion and contraction. In the basic and neutral groups of refractories there was an inviting prospect for the application of manufacturing skill. Some of the present temporary difficulties in the supply of materials he himself was overcoming by fastening working surfaces of chromite, magnesite, or other materials not liable to corrosion on to ordinary fire or silica bricks. Some samples of these faced bricks were exhibited. As a manufacturer he advocated the closest possible union between the chemist and the craft in the carrying out of organized investigations—mere laboratory tests were insufficient—into the commercial value of the minerals, chromite, magnesite, graphite, and others, reported that evening as abundant in the colonies. Above all, improved education was necessary in those who were to carry on the business of making refractories; the men of science must come down to them and talk to them freely of principles and facts, and so accelerate a rise of specialized intelligence among clayworkers.

Mr. **E. P. Page** (Sheffield), who spoke on "The Classification of Refractory Materials and Some Notes on Method and Points for Investigation," briefly introduced his paper as follows:

This paper is confined in the main to the materials used in the heavy industries. To cover the whole field of refractory materials and their application in large branches of industry would be beyond the range of accomplishment in any single paper. The collection and tabulation of facts is a laborious task, since much of the information is only to be obtained by the association of those who are engaged in industrial practice. Further, the science of refractory materials is in its infancy, and much of that which is considered to be the fact requires verification. An easy method of classifying refractory materials has been to divide them into three sections, namely, acid, basic, and neutral, according to their chemical composition and their behavior toward each other and the acid or basic compounds brought into contact with them under such conditions as are favorable for reaction to take place. The classification is somewhat arbitrary, because a clay such as china clay must be expected from its chemical composition to be a neutral material, which experience shows is not the case, and it is customary to include all refractory clays in the acid class. The essential property of any material claimed to be refractory is stability at the temperatures to which it is exposed, with sufficient reserve of stability to resist chemical and mechanical influences externally applied. The first quality is a classification of pure refractori-

ness, and the second is one of refractoriness plus skill in application. However, since purely basic or purely acid conditions seldom exist, the successful issue is generally the result of compromise, a certain degree of refractoriness per se being sacrificed in favor of an increase of refractoriness against other things. Materials belonging to the acid class are always used where it is a case of refractoriness toward heat, because they are widely distributed and comparatively low in first cost and lend themselves rightly to adaptation to all purposes. Suitable basic and neutral materials, on the other hand, are not so widely distributed, and possess in important instances inherent properties which render them difficult of application.

Mr. **W. J. Jones,** of the Ministry of Munitions, said the discussion had brought out clearly the necessity for closer co-ordination between science and practice, between the laboratory on the one hand and the brickmaker and the steel-maker on the other. It was the enormous increase of production necessitated by the war that had brought home to the steel industry the importance of their refractory materials. He urged as a further reason for co-ordination the different results that so often were obtained with the very same material in different works.

Mr. **A. A. McDougall Duckham** of the Ministry of Munitions, also emphasized how much the output of munitions depended on refractories. It was clear that Great Britain had at home and in the Empire ample material to enable us to hold our own.

Dr. **W. Rosenhain,** of the National Physical Laboratory, spoke of the necessity for paying attention to the highest class of refractories now that metallurgists, especially in the electric furnace, were utilizing very high temperatures. Metallurgists should know all about materials like carborundum, alundum, silicon and similar products now being produced at Niagara Falls. There was great promise in zirconia, especially the highly purified material. An analysis of crude zirconia (about 75 per cent pure) was given. This material fell far short of pure ZrO_2 in refractoriness, but still bricks made of it would resist temperatures up to 1600 deg. C. To get the best results it was essential to shrink the material at a much higher temperature than that it would have to stand eventually, particularly because it was so bad a conductor of heat. The crude zirconia was greatly improved by removing the chief flux, namely the iron oxide, with hydrochloric acid. Zirconia bricks as now purified for optical purposes do not frit until well over 2000 deg. C. Dr. Rosenhein went on to discuss the cracking of refractories. This was caused by physical forces involving nothing but determinable constants, and the coefficient of thermal endurance could be worked out, as had been done for glass.

Professor **T. Turner** (Birmingham) reminded the meeting that the subject was also of interest to the glass, pottery, and porcelain industries, and he referred to the work on glass being done at Sheffield University. Speaking of the relation between porosity and the packing of the grains of which the material is built up, he pointed out that round grains did not necessarily mean an open and sharp a close packing. Small round particles in the interstices of larger round ones, as one might have in sand, gave the closest grain. Porosity had been measured by drawing air through at a known rate.

Dr. **R. S. Hutton** (Sheffield) pleaded for more work at the very high temperatures of the electric furnace. For example, the properties of completely shrunk magnesia were quite different from those of ordinary calcined, and the shrinking could be economically effected electrically.

Dr. **W. H. Hatfield** (Sheffield) remarked on the work to be done on the resistance of refractories to slag erosion. He gave examples of the great disparity in behavior of different grades of silica bricks. Before more progress was possible much more accurate instruments for registering high temperatures were necessary; at present, calibration between 1000 deg. and 2000 deg. C. was difficult and uncertain.

Professor **F. G. Donnan** spoke of the necessity for a standard quantitative specification for silica bricks.

Dr. **P. G. H. Boswell,** of the Geological Department, Imperial College of Science and Technology, read a paper on "Refractory Sands."

Many of the sands used for refractory purposes are not true sands in the geological sense; they frequently contain a proportion of refractory clay, etc. There is no doubt that we can replace from home resources a large proportion of the refractory sands hitherto imported from abroad, but the extent to which this can be done will not be completely known until further investigation of the properties of suitable materials and satisfactory substitutes has been carried out. The admirable work of H. M. Geological Survey in collecting, recording, and, in part, subjecting to analysis supplies of refractory materials worked in this country needs to be supplemented by much research work, for in certain directions the properties of desirable sands, for example, are not fully known, and geologists do not know what to look for. Pure academic work in the shape of the application of modern petrographic methods to the investigation of sands is urgently required, but the final tests of the suitability for particular purposes must always be on a commercial scale in the works. On the academic side, we need far more results of experiments and observations carried out on certain definite lines and under standard conditions with continuity secured by the retention of one worker or set of workers in each direction. The time has passed for the scattered and haphazard methods and results of which we have had so large a number. The pure scientific work will indicate the likely materials to be tried in industrial practice and will eliminate the improbable materials. The closest British analogues to the very suitable foreign materials will then be found.

The refractory sands used in industry may be divided into three chief classes: (a) the high silica sands (with 98.99 or more per cent of SiO_2), (b) the high silica and alumina sands bearing variable proportions up to 20 per cent alumina, as kaolin, etc., and little else but silica, (c) sands for greensand-molding, carrying a strong and highly refractory natural clay bond. All class (a) sands hitherto imported may be replaced from the abundant and excellent British supplies. (The economic factors, freight, etc., will have to be considered.) We have also valuable deposits of class (b), but so far as those sands of class (c) which are used for high temperature steel-molding are concerned, it must be admitted that the best of foreign sands hitherto used here have not been equaled by known British resources. The reason for this is twofold: in the first place the peculiar properties of the Belgian red or yellow sands, to take a concrete case, have never been thoroughly investigated with the view of finding substitutes; in the second, we do not yet know all our British sand and related deposits at all thoroughly. At least two geological horizons in this country should be thoroughly searched in this connection: they are the Pliocene and the Lower Cretaceous. The Tertiary and Cretaceous deposits of the southwest of England are particularly deserving of attention.

In brief, research on British and foreign refractory

sands is desirable in the following directions (among others):

(1) Mechanical analyses, to gain more accurate ideas of grading, carried out scientifically.

(2) Chemical analyses of each grade, not bulk analyses.

(3) Mineral analyses, to realize the importance of constituent minerals, especially those prone to decomposition which yield the "bonds" of these sands.

(4) The water-holding capacity at 10 deg. intervals at temperatures below 110 deg. and at suitable but greater intervals above.

(5) The conductivity.

(6) The refractoriness of each grade.

(7) Pore space and permeability.

It is to be hoped that before long a detailed account of British resources of refractory sands, with analyses and notes on their peculiar properties, may be in the hands of manufacturers and others. Such a report by the speaker on British resources of sands suitable for glass-making, with notes on certain highly siliceous materials suitable for refractory purposes, was just being published at the request of the Ministry of Munitions. These glass-sands fall under classes (a) and (b) above, but the resources suitable for refractory purposes are far larger than those for glass-making.

Finally, co-ordination of the work of the four classes of interested people (users of refractories, the makers of refractories, the collectors and analysts of raw materials, and the research workers) is urgently required to prevent serious overlapping and to insure a minimum loss of effort and a maximum of benefit to the country, which as far as possible should be self-supporting in the matter of raw materials for key-industries.

The general discussion was resumed by Mr. **E. Kilburn Scott,** who confirmed from his own experience with flame-arc furnaces what Dr. Hutton had said about the possibility of completely shrinking magnesite.

Dr. **W. C. Hancock** spoke of the application of certain organic dyes to etch refractory materials much as metals were etched. This method, coupled with Professor Fearnsides', would be a powerful weapon for elucidating internal structure. He was working on coke-oven firebricks in this direction in conjunction with Professor Bone at the Imperial College of Science and Technology.

Here the president called on Mr. **Ezer Griffiths** of the National Physical Laboratory to read his paper on "The Thermal Conductivity of Materials employed in Furnace Construction."

The paper dealt with the methods employed for investigating the thermal conductivity of bricks and tiles of commercial sizes.

One of the practical difficulties was the attainment of a uniform temperature over the hot face of the sample, since the surfaces were always irregular. It was found possible to obtain good thermal contact as well as a very uniform distribution of temperature over the surface by the use of a shallow bath of molten metal electrically heated.

In high temperature experiments the heating was effected by making the test sample a part of the walls of a large muffle.

The heat transmitted was measured by a flow calorimeter fitted with a guard ring.

A compact form of thermoelement was described: the two wires (Pt — Pt 10 per cent Ir) being separately insulated by silica capillaries and both inclosed in a silica sheath of about 5 mm. diameter. The sheath was closed at the end in the form of a bulb containing the junction. The thermoelement was employed for exploring the distribution of temperature in the metal bath, and for this purpose it was bent into an L shape.

Values of the thermal conductivity and its variation with temperature were given for two typical materials employed for thermal insulation—the one composed principally of diatomaceous earth baked at a high temperature to form a rigid brick of friable texture; the other manufactured by blowing steam through molten blast-furnace slag, which converts it into a product bearing a resemblance to cotton-wool. This material was tested in the form of a mat, the faces being covered with wire meshing.

Dr. **J. A. Harker** commented on the value and accuracy of Mr. Griffiths' work on a subject presenting serious experimental difficulties.

He added some information on the properties of zirconia, which, if fine enough, would stand being plunged into water at a white-heat temperature.

Written communications to the discussion were received from the following gentlemen:

Mr. **W. Donald** (Glasgow), who sent in some specimens of raw and calcined Greek magnesite and magnesite cement and bricks, wrote that they were having to make substitutes for Austrian magnesite bricks, and they were therefore adding some 8 per cent Fe_2O to the Greek magnesite, which was too pure, to approximate its composition to the Austrian. Mr. Donald also exhibited some Indian and Rhodesian chrome ore and cements and bricks made therefrom. He went on to suggest that the use of dolomite in conjunction with magnesite for basic steel furnaces needed serious consideration. He believed that when, as often, the dolomite boils with the metal active ferrates of lime may be formed, and the result is destructive to the magnesite foundation of the furnace. He had recently suggested to the Iron and Steel Institute the desirability of drawing up standard specifications for bricks used in the iron and steel industries. Finally, he touched on the question of linings for electric furnaces, and he incidentally mentioned the possibilities of Serbia, with its minerals and plentiful water power, as an electrometallurgical center.

Mr. **A. B. Searle** (Sheffield) expressed his agreement with the view that chemical analysis was secondary in importance to some of the physical characteristics of firebricks, and he had himself chiefly relied on physical and microscopical methods of examination. Referring to the desire for co-ordination that had been expressed, he reminded the meeting that they had a trade journal which devoted special attention to the scientific and technological aspects of refractories. Backwardness was largely due to the fact that most of the firms concerned were too small to undertake research work. Furthermore, research, to be useful, must be carried out by specialists who had practical knowledge of the industry. The manufacturers should combine together and retain such men, leaving the universities to concentrate on questions of academic interest, for which they were specially fitted.

Mr. **T. Allen** (Dudley) said the great difficulty in making improvements in manufacturing process in this industry was to prove the value of any change, because this might take years to realize. Laboratory tests were often inconclusive. Nevertheless, the gas-retorts of to-day were meeting the severe demands put upon them. An important point was the economy of not running retorts after their efficiency has dropped, say in 1000 to 1200 days. He did not think German or American gas installations showed better results than the best of the British. He paid a tribute to the work of the Refractory Materials Committee.

Mr. **F. Deansfield** (Oldham) wrote of the desirabil-

ity of inducing manufacturers to adopt more uniform methods. He also drew attention to the enormous loss of refractory clays lying under coal seams, due to the winning of the coal only, so that it afterwards becomes too dangerous and costly to win the clay. These materials should be carefully reserved, if necessary by legislation. He hoped the society would consider this problem.

Mr. **Alleyne Reynolds** wrote that he knew of an Austrian works having clamped arches of silica brick 8 ft. in width that had been in use for over twenty years, whereas we were satisfied to produce silica bricks with 20 per cent expansion. The same firm paid more attention to properly heating their ladles and shaping their nozzles than any British firm of his acquaintance. There should be more co-operation between the steel makers and the makers of refractories. The keeping of so-called "trade secrets" was to be deprecated; the most successful manufacturers were those who showed, like their president, a large-minded scientific spirit. Mr. Reynolds disagreed with the president as to worn clay nozzles accounting for slag inclusion in steel ingots, which he thought resulted from reactions in the dissolved FeO and FeS. He was suspicious of magnesite nozzles, from which minute particles would probably be carried into the mold. He added some interesting information on the proper method of casting steel from the ladle and on the effect of iron oxides in firebricks. Fe_2O_3 and Fe_3O_4 seem to increase the refractoriness of bricks exposed to oxidizing atmospheres; any iron oxide is detrimental in reducing atmospheres. The bricks forming the regenerators of open-hearth furnaces take up much more iron in the gas than in the air chambers, and their regenerative efficiency is increased. The subject needs proper investigation, as does also the volatilization of refractories, particularly magnesite, at low temperatures, such as 1300 deg. C., perhaps due to catalytic action. A properly designed electric furnace was, he thought, the only remedy.

Mr. **Charles R. Darling** in view of the relatively high conductivity of firebricks as shown by Mr. Griffiths, drew attention to the suggestion of Hutton and Beard, made before the society in 1905, that furnaces should be lagged with a highly insulating substance. Experiments by FitzGerald and by him had confirmed the great saving anticipated. It was strange that metallurgists had not adopted the idea.

A very useful refractory was alundum, of which Messrs. Baird and Tatlock exhibited specimens. It melted at 2050 deg. C. and had no action on platinum at high temperatures, so was suitable for platinum-wound electric furnaces. A non-porous variety was useful for sheathing pyrometers and is less corroded by molten metals than silica. The question of the electrical conductivity of refractories had been little studied; in a research he was engaged upon he needed one that was non-conducting at 1600 deg. C., and which was not easily attacked by metallic oxides.

Standardization of Carbon Electrodes for Furnaces.—From the London *Electrician*, Nov. 17, we learn that as a result of war conditions in Germany carbon electrodes for electric furnaces are now being standardized. According to the new rules round carbons for steel furnaces are to be made in sizes varying in thickness from 100 mm. upward by steps of 25 mm., the tolerance varying from 3 mm. to 6 mm. according to size. For rectangular electrodes used with other kinds of furnaces a standard size of 500 mm. square is proposed. For the time being the standard length is fixed at 2 meters, but all lengths may be valued in multiples of 20 mm. Tables for dimensions of threads are under consideration.

New York Meeting of American Association for the Advancement of Science and Associated Societies

The sixty-ninth meeting of the American Association for the Advancement of Science will be held in New York City from Tuesday, Dec. 26, to Saturday, Dec. 30. Of the general addresses on the program three are of especially great importance. On Tuesday evening the retiring president, Dr. W. W. Campbell, of Lick Observatory, will deliver his address on "The Nebulæ." On Wednesday evening Dr. Simon Flexner, of Rockefeller Institute, will speak on "Infantile Paralysis." On Thursday evening Prof. A. A. Noyes, of Massachusetts Institute of Technology, will speak on "The Production of Nitrogen."

SYMPOSIUM ON STRUCTURE OF MATTER

Sections B (Physics) and C (Chemistry) of the A. A. A. S. will hold a joint meeting with the American Chemical Society, the American Electrochemical Society, and the American Physical Society on Wednesday, Dec. 27, at 10 a. m. and 2 p. m. at Columbia University.

The morning session will be opened by the address of the President of the American Physical Society, Robert M. Millikan, on "Radiation and Atomic Structure." Papers will then be presented by Gilbert N. Lewis on "The Atom and Chemical Valence," by Robert W. Wood on "Molecular Resonance and Atomic Structure," and by Irving Langmuir on "The Atomic Theory." The discussion will be opened by Wm. Duane and John M. Nelson.

In the afternoon session papers will be presented by William. J. Humphreys on "The Relations of Magnetism to the Structure of the Atom," by Albert P. Wills on "The Relations of Magnetism to Molecular Structure," by Wm. D. Harkins on "The Evolution of the Elements as Related to the Structure of the Nuclei of Atoms," and by Lander W. Jones on "Electromerism, a Case of Chemical Isomerism Resulting from a Difference in Distribution of Valence Electrons." The discussion will be opened by K. George Falk.

On Thursday, Dec. 28, at the College of the City of New York, the retiring vice-president of Section C (Chemistry), Prof. William McPherson, will deliver his address on "Asymmetric Syntheses and Their Bearing Upon the Doctrine of Vitalism."

Section D (Engineering) of the A. A. A. S. will hold a session in the Engineering Societies Building, 29 West Thirty-ninth Street, on the invitation of the American Society of Civil Engineers, the American Institute of Electrical Engineers, the American Society of Mechanical Engineers, and the American Institute of Mining Engineers. At this meeting Dr. Bion J. Arnold will deliver his address as retiring chairman of Section D, and there will be addresses by representatives of the engineering societies, followed by a reception to engineers and those working in sciences relating to engineering. This meeting will be held on the evening of Friday, Dec. 29.

An exhibition of chemical and physical products and apparatus will be held at Columbia University on Wednesday, Thursday, and Friday, Dec. 27, 28 and 29.

The J. P. Devine Company, Buffalo, N. Y., has issued bulletin No. 105 describing apparatus for the chemical and allied industries, including autoclaves; reduction, nitrating, fusion and tilting kettles; vacuum pans, vacuum evaporators, jacketed pans for drying, evaporating and crystallizing; digestors, and other chemical apparatus. Most of the illustrations are shown in perspective and are quite attractive.

The Electrolytic Oxidation of Sulfurous Acid

By M. De Kay Thompson and N. J. Thompson

The electrolytic oxidation of sulfurous acid gas is a process that may become of technical importance because of the increasing use of unattackable anodes in winning copper direct from the ores. If sulfur dioxide is supplied to the anode, the voltage is reduced because the dioxide acts as a depolarizer, and is itself oxidized to sulfuric acid. There seems to have been very little work done in the study of this reaction.

The use of sulfur dioxide as depolarizer in the recovery of pure copper from copper sulfate solution obtained by leaching the copper ores was patented in 1902 by Tossizza (U. S. Patent No. 710,346), but no information is given as to the current efficiency of the oxidation. The only other reference we have found is an article by A. Fischer and G. Delmarcel, entitled "L'Oxidation Electrolytique de L'Acide Sulfureux" (Chem. Zentralbl. 1910, ii, p. 603; Bul. Soc. Chim. Belgique 24, pp. 236-37). The authors used an earthen ware cup as diaphragm, containing a cylindrical nickel cathode and a cylindrical platinum gauge anode surrounding the diaphragm. The porous cup was filled either with sulfuric acid or sodium sulfite. Outside the cup there was a solution or sulfur dioxide, the concentration of which varied from 1 to 5 per cent. The current density was about 0.0075 ampere per square centimeter. They found that catalysts, such as copper acetate, do not increase the current yield in sulfuric acid, since the platinum acts as a catalyst itself. Better results were obtained with low than with high concentrations of sulfur dioxide.

In the following experiments the anode solution was kept saturated by passing a current of sulfur dioxide, and absorbing the excess in a soda lime 1.2 centimeters in diameter and 38 centimeters long. This absorbs the dioxide, but allowed any oxygen formed in the electrolysis to pass.

The dioxide was made by the action of sulfuric acid on copper wire, 1.8 millimeters in diameter. The rate of evolution was controlled by regulating a gas burner under the 500 cubic centimeter generating flask. The dioxide was washed in a solution of sulfurous acid and then passed to the anode compartment of the cell, which consisted of a porous cup, 5 centimeters in diameter and 15 centimeters high. The cup was glazed at the top inside and outside and was closed by a rubber stopper with holes for the supply and delivery of gas and for the anode connection.

The anode was a sheet of smooth platinum of 25.8 square centimeters, including both sides. The sulfur dioxide tube delivered immediately under this electrode. The cathode was a nickel cylinder, surrounding the porous cup. The whole was contained in a glazed porcelain vessel of the smallest possible size.

The cell was cooled by placing in a pail where water circulated. The temperature of the cathode solution was 20 deg. C., the anode solution was about 5 deg. higher.

The gas coming from the anode compartment passed the soda lime tube referred to above and then passed to a Hempel burette with a three-way stop cock by means of which the oxygen could be measured continuously before allowing to escape. The oxygen generated represented a current loss, and was used as a measure of this loss.

Any oxygen in the gas escaping from the anode compartment must be due to a liberation of sulfate ions which react with the water present. There could have been no reactions other than this or the oxidation of sulfurous acid, for the only other reaction possible is the union of two sulfate radicals to form persulfuric acid. This acid, however, is formed only at low temperatures and with the simultaneous evolution of oxygen. Moreover, it could not be formed in the presence of a strong reducing agent like sulfurous acid.

The method of experimenting consisted in making up solutions of sulfuric acid of different concentrations, with which the cell was filled, both anode and cathode compartments. The electrolysis was then carried out with different current densities from 0.19 to 0.50 ampere per square centimenter. Before starting each run, sulfur dioxide was passed through the system (except the soda lime tube) for about an hour to remove all the air.

The total amount of electricity passing the cell was determined by a copper coulometer. The current efficiency was determined by computing the amount of copper equivalent to the total oxygen evolved, subtracting this from the copper deposited in the coulometer and then dividing by the copper deposited.

The results obtained are tabulated below and are shown in Fig. 1.

DATA (OBSERVED AND CALCULATED)

RUN NO. 1. 10 PER CENT H_2SO_4. BAROMETER, 761 MM. TEMP., 22.0 C.

Current	Voltage	Coulometer Weight Cu.	Volume of Oxygen		Current Efficiency
			Obs.	Corr.	
5.0	4.00	3.01	No gas	.....	100.0
5.0	3.95	1.21	No gas	.....	100.0
7.0	4.20	2.39	No gas	.....	100.0
7.0	4.10	1.58	No gas	.....	100.0
9.0	4.30	1.44	No gas	.....	100.0
9.0	4.25	1.22	No gas	.....	100.0
11.0	4.45	1.08	No gas	.....	100.0
11.0	4.40	1.07	0.6 cc	0.6 cc	99.3
13.0	4.50	1.11	1.2	1.1	99.5
13.0	4.45	1.19	0.9	0.8	99.7

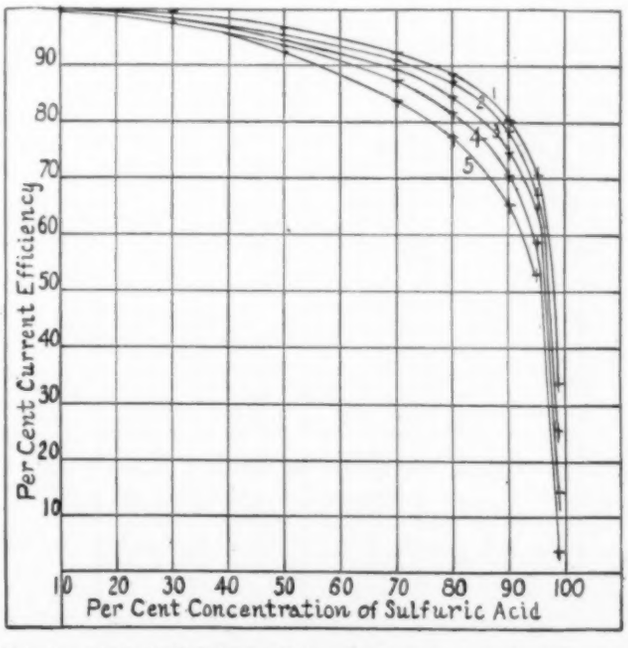


FIG. 1—SHOWING THE RELATION BETWEEN CURRENT EFFICIENCY, CURRENT DENSITY AND CONCENTRATION OF SULFURIC ACID IN THE ELECTROLYTIC OXIDATION OF SULFUROUS ACID. THE CURRENT DENSITIES WERE 19, 27, 35 AND 50 AMPERES PER SQUARE DECIMETER FOR THE GRAPHS 1 TO 5 RESPECTIVELY

Run No. 2. 30 per Cent H_2SO_4. Barometer, 761 mm. Temp., 22.0 C.

Current	Voltage	Coulometer Weight Cu.	Volume of Oxygen		Current Efficiency
			Obs.	Corr.	
5.0	4.15	2.38	2.1	1.9	99.5
5.0	4.15	1.09	1.0	0.9	99.5
7.0	4.50	3.74	15.3	13.8	98.0
7.0	4.40	1.19	4.9	4.4	98.0
9.0	4.85	2.04	7.3	6.6	98.2
9.0	4.75	1.18	4.2	3.8	98.2
11.0	5.05	1.74	7.2	6.5	97.9
11.0	5.05	1.04	4.3	3.9	97.9
13.0	5.35	1.59	7.5	6.8	97.6
13.0	5.30	1.18	5.6	5.1	97.6

Run No. 3. 50 per Cent H_2SO_4. Barometer, 761 mm. Temp., 22.0 C.

Current	Voltage	Coulometer Weight Cu.	Volume of Oxygen		Current Efficiency
			Obs.	Corr.	
5.0	4.15	1.75	12.2	11.0	96.5
5.0	4.10	1.20	8.3	7.5	96.4
7.0	4.55	2.38	21.4	19.3	95.5
7.0	4.45	1.12	10.2	9.2	95.5
9.0	4.95	0.94	10.6	9.5	94.5
9.0	4.90	1.01	11.2	10.2	94.4
11.0	5.25	1.46	19.0	17.1	93.5
11.0	5.15	1.15	14.9	13.5	93.3
13.0	5.50	1.24	18.1	16.3	92.6
13.0	5.40	1.13	16.5	14.9	92.6

Run No. 4. 70 per Cent H_2SO_4. Barometer, 750 mm. Temp., 230 C

Current	Voltage	Coulometer Weight Cu.	Volume of Oxygen		Current Efficiency
			Obs.	Corr.	
5.0	4.80	1.64	23.6	21.1	92.7
5.0	4.70	1.01	14.4	12.9	91.8
7.0	5.60	1.66	29.3	26.3	91.0
7.0	5.50	1.21	21.4	19.2	91.0
9.0	6.75	0.778	17.0	15.2	89.0
9.0	6.70	0.811	17.7	15.8	89.1
11.0	6.80	1.044	26.6	23.9	87.1
11.0	6.80	0.997	25.5	22.8	87.0
13.0	7.60	1.29	40.8	36.6	83.8
13.0	7.70	0.910	28.8	25.8	83.9

Run No. 5. 80 per Cent H_2SO_4. Barometer, 761 mm. Temp., 22.0 C.

Current	Voltage	Coulometer Weight Cu.	Volume of Oxygen		Current Efficiency
			Obs.	Corr.	
5.0	5.05	0.842	19.0	1.71	88.5
5.0	5.00	1.09	23.5	21.2	88.5
7.0	5.90	0.851	21.6	19.4	87.0
7.0	5.85	0.980	25.1	22.6	87.1
9.0	6.55	0.792	24.3	22.0	84.1
9.0	6.50	1.81	56.0	50.5	84.3
11.0	7.05	0.812	29.4	26.6	81.5
11.0	6.90	0.468	16.9	15.2	81.6
13.0	7.70	0.588	26.6	24.0	76.9
13.0	7.50	0.612	27.6	24.8	77.1

It is evident from these results that sulfurous acid is easily oxidized on platinum anodes to sulfuric acid of any concentration below 95 per cent. The concentration of the sulfuric acid has a great effect on the current efficiency. The current density also has a decided effect on the efficiency, but to a less degree than

Run No. 6. 90 per Cent H_2SO_4. Barometer, 750 mm. Temp., 23.0 C.

Current	Voltage	Coulometer Weight Cu.	Volume of Oxygen		Current Efficiency
			Obs.	Corr.	
5.0	6.60	0.817	31.9	28.6	80.2
5.0	6.00	0.799	31.3	28.1	80.1
7.0	7.10	0.642	28.4	25.5	77.5
7.0	6.90	0.905	39.9	35.8	78.8
9.0	7.60	0.738	37.4	34.6	73.4
9.0	7.45	0.678	34.2	30.6	75.2
11.0	8.50	0.773	44.7	40.1	70.5
11.0	8.50	0.681	39.4	35.3	70.6
13.0	9.40	0.771	52.8	47.4	65.1
13.0	9.55	0.749	51.5	46.2	65.0

Run No. 7. 95 per Cent H_2SO_4. Barometer, 762 mm. Temp., 22.0 C.

Current	Voltage	Coulometer Weight Cu.	Volume of Oxygen		Current Efficiency
			Obs.	Corr.	
5.0	7.45	0.977	56.8	51.2	70.3
5.0	7.10	0.879	51.1	46.0	70.4
7.0	8.05	0.701	44.4	40.0	67.6
7.0	8.10	0.869	56.0	50.5	67.1
9.0	8.90	0.751	52.2	47.0	64.4
9.0	9.15	0.750	50.5	45.5	65.5
11.0	9.80	0.622	50.6	45.6	58.3
11.0	10.05	0.692	56.8	51.1	58.1
13.0	11.60	0.786	72.5	65.4	52.7
13.0	12.00	0.673	61.1	55.1	53.6

Run No. 8. 98.7 per Cent H_2SO_4. Barometer, 762 mm. Temp., 22.0 C.

Current	Voltage	Coulometer Weight Cu.	Volume of Oxygen		Current Efficiency
			Obs.	Corr.	
5.0	9.05	0.720	93.8	84.5	33.3
5.0	9.10	0.717	92.6	83.5	33.9
7.0	11.25	0.406	59.3	53.4	25.3
7.0	11.20	0.734	107.2	96.7	25.2
9.0	14.15	0.418	69.2	62.3	15.2
9.0	14.25	0.751	125.2	112.9	14.6
11.0	19.40	0.404	75.8	68.3	3.9
11.0	20.10	0.691	131.1	118.1	3.0

Summary of Current Efficiencies for the Different Current Densities and Acid Concentrations

Current Density Amp. per Sq. Dm.	Per Cent Sulfuric Acid							
	10	30	50	70	80	90	95	98.7
19	100	99.5	96.5	92.3	88.5	80.2	70.3	33.6
27	100	98.0	95.5	91.0	87.1	78.2	67.4	25.3
35	100	98.2	94.5	89.1	84.2	74.3	65.0	14.9
43	99.7	97.9	93.5	87.1	81.6	70.6	58.2	3.5
50	99.6	97.6	92.6	83.9	77.0	65.1	53.2	....

the concentration of the acid. The efficiency falls with increased current density. This is what might be expected from analogy with other cases. For example, the cathodic reduction of hypochlorite is diminished by increasing the current density.

Summary: The current efficiencies of the electrolytic oxidation of sulfurous acid in sulfuric acid of concentrations from 10 to 98.5 per cent with current densities from 19 to 50 amperes per square decimeter were measured. A platinum anode and a nickel cathode were used, separated by a clay diaphragm. The results show that this oxidation takes place with high current efficiencies even in strong sulfuric acid solu-

tions. For a given sulfuric acid concentration the current efficiency decreases with increasing current density.

Massachusetts Institute of Technology,
Cambridge, Mass.

The Selection of Centrifugal Pumps*

By D. McEoceid

In the commercial offices of firms manufacturing such articles as centrifugal pumps, the design of which requires technical ability of rather more than average quality, it is desirable that the methods of dealing with clients' inquiries be accurate, as flexible as possible, and easily checked. In many cases the selection has to be made from a tabulation of previously calculated outputs, necessitating, for the use of the commercial staff, approximate methods of interpolation when non-listed outputs are required. These are not, in general, accurate for wide variations from the list, and unless used with discretion are liable to result in serious errors. Output curves of the performance of each standard size of pump for various speeds are sometimes employed. Selection by means of these is slow and laborious, and the process necessitates the provision of a large number of curves. In order to assist engineers whose commercial pursuits do not as a rule permit of the leisure which would enable them to make themselves fully acquainted with all the subtleties of the centrifugal pump, it is well to have available an easily operated and sufficiently accurate procedure. Methods which enable a selling staff to decide, on short notice, which machine will best fulfil certain required conditions, without having to refer to the designers, have their double value in the saving of the time of the latter and in the impressing of the client.

It is customary for manufacturers of centrifugal pumps so to design them that they can be utilized for as great a variety of heads, speeds and quantities as possible. The evolution of a complete range of pumps generally results in the development of a series of groups, each group consisting of a number of pumps with gradually-increasing diameters of impeller, and with a definite ratio of impeller width to diameter and other dimensions in proportion, so that the pumps of a group are symmetrical. Thus arranged, almost any conceivable output can be provided for by selecting that type of pump and diameter of impeller most suited to the form of drive proposed and the general requirements of the installation.

The method described below has been developed to suit such standardized lines of pumps, and in addition to overcoming most of the difficulties usually met with, provides also in a convenient form the complete characteristic of the pump. It will simplify the description to take the performance of an actual pump—Table I—and to employ the following notation:

*From *The Engineer* (London), Oct. 13, 1916.

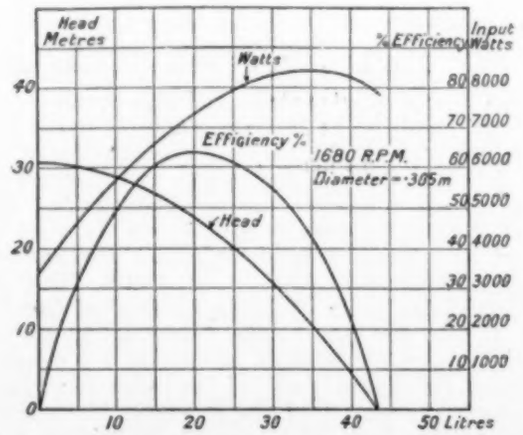


FIG. 1—CHARACTERISTIC CURVES AT CONSTANT SPEED

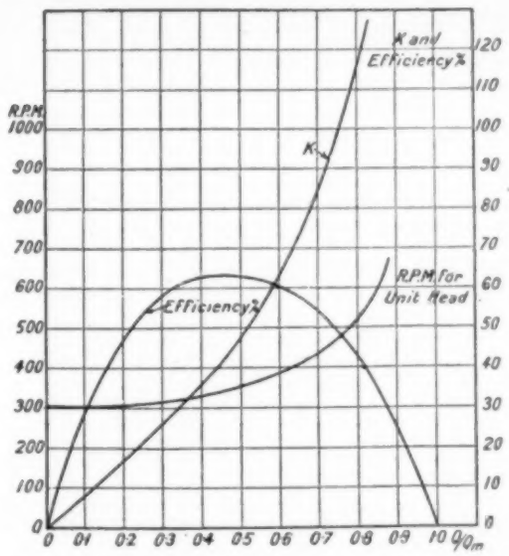


FIG. 2—VALUES OF EFFICIENCY K. AND R.P.M.

TABLE I

Q, Litres/Sec.	h, Metres	Watts, Input	Efficiency, Per Cent	n, R.P.M.
0	30.6	3350	0	1680
7.56	29.6	5120	42.8	1680
15.1	26.8	6520	61.0	1680
22.7	21.8	7750	62.5	1680
26.0	19.2	8010	60.1	1680
30.2	15.1	8280	54.0	1680
35.0	10.3	8420	42.5	1680
37.8	7.0	8400	31.0	1680
43.5=Qm	0	7840	0.0	1680

n = revolutions per minute.
Q = quantity of water, litres per second.
h = external head of the pump, metres.
D = diameter of the impeller, metres.
v = peripheral speed, metres per second.

The two following relations are true for a given pump, within reasonable limits, where A and B are constants, depending on the type and the position on the h-Q characteristic:

$$h = A \times n^2.$$
$$Q = B \times n.$$

It is also a property of similarly proportioned pumps, when operated at the same peripheral speed of impeller, that at corresponding points on their pressure-quantity characteristics the following relation holds:

$$Q/D^3 = \text{constant}.$$

The external heads which would be produced by such pumps under these conditions are equal. If, then, for a given pump the characteristic curves at constant speed be those shown in Fig. I—the figures for which are given in Table I—and if Q_m be the maximum discharge the pump is capable of at that speed, the discharge for various conditions of head may be represented as a proportion of Q_m. The abscissæ then become $Q/Q_m = 0.1$, 0.2, etc. For each value of Q/Q_m the revolutions per minute n_1 at which one metre—unit—head can be obtained is calculated from the relation $h = A\,n^2$. In addition the actual values of Q are reduced to those which would be obtained at these speeds—and at unit head—from the relation $Q = B\,n$. From

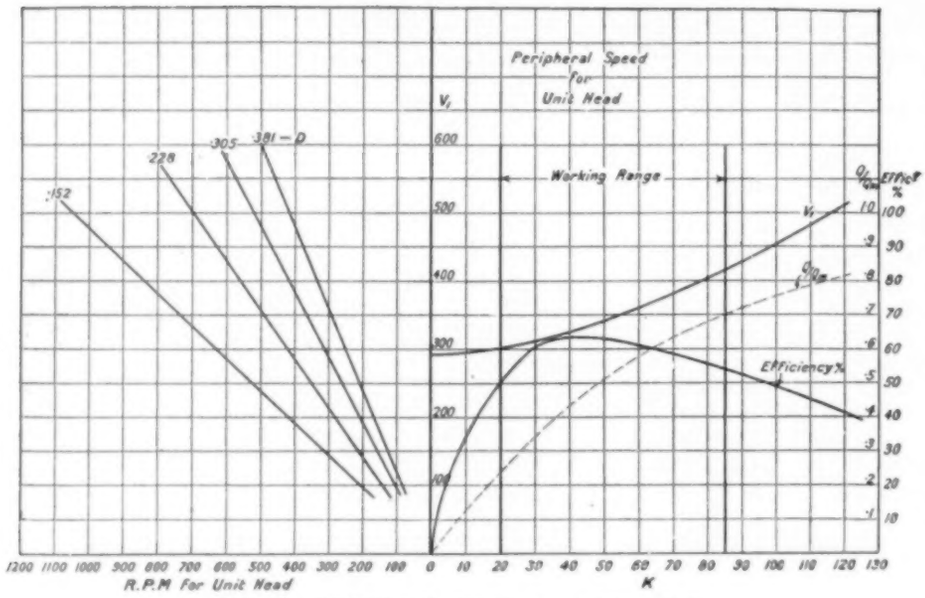


FIG. 3—PERIPHERAL SPEED FOR UNIT HEAD

these new values of Q at the reduced speeds, the values of $Q_1/D^2 = K$ are then calculated. The values of Q/Q_m, revolutions per minute and K are shown on Table II and plotted on Fig. 2. The latter gives the characteristics in another form and for the specific diameter of pump presents all the information necessary to obtain the performance curve at any speed. In order to make this information available for any pump of symmetrical design, it is necessary to introduce the peripheral speed at which one metre head is developed, this being easily calculable from the known diameter of the pump in question and the speed shown on Fig. 2.

The resulting curves are plotted on Fig. 3, introducing at the same time, for assumed standard diameters, the revolutions per minute necessary to produce unit head. The selection by means of these curves is made in the following manner, calculation sheets being used of the form suggested:

Form A.—From the specified head and volume, the revolutions per minute not being specified, the output at unit head, Q_1, is calculated from the following relation $Q = \frac{1}{Q}\sqrt{h}$.

Form B.—From the standard curves, using the formula $K = Q_1/D^2$, the value of K is found for various standard diameters. (This is conveniently done by means of the slide rule.)

Only those values of K are taken which from an inspection of the curves result in a reasonable efficiency value. The values of Q/Q_m, efficiency and peripheral speed are taken from the curves and tabulated—Form C. The revolutions per minute and power required are then very simply calculated, and additions having been made for friction losses, the most suitable pump is selected.

In the case shown, for continuous running, the third pump is obviously to be chosen. For occasional work, where efficiency is not an important matter in relation to first cost the second pump, particularly for electrical drive, would be selected. A smaller motor would be required as well as the smaller pump.

For other cases—as, for instance, alternating current motor direct-coupled drive—the speeds available are limited, and for such cases this method enables one rapidly to select the pump which for such limitations, will give the best results.

Other uses of the standard curves will present themselves; *e.g.*, the comparison of the performance of various types of pump in which the particular qualities of each are made prominent, the calculation of outputs for varying conditions of heads or speeds.

TABLE II

Q/Qm	R.P.M. for Unit Head	r_1.	Q_1 at Speed for Unit Head	$K=\frac{Q_1}{D_2}$	Efficiency, Per Cent
0	304	291	0	0	0
.174	309	296	1.39	14.95	42.8
.348	324	310	2.91	30.3	61.0
.522	360	345	4.87	52.0	62.5
.6	383	367	5.93	63.9	60.1
.694	432	414	7.78	83.5	54.0
.805	524	502.5	10.9	117.0	42.5
.87	635	609	14.3	153.5	31.0
1.0	∞	....	.....	.....	0.0

Form A

	Quantity	Head
Output required	20	23.8
Output reduced to unit head	$4.1=Q_1$	1

Form B

D_1, Metres	K for Std. D.	Q/Qm	Efficiency, Per Cent	r_1, Metres/Min.	R.P.M. for Unit Head n	
.152	178	Outside the working limits				
.228	79	.675	55.8	402	562	$K=\frac{Q_1}{D_2}$
.305	44.2	.47	63.5	332	345	
.381	28.3	.322	59.2	309	259	

Form C

D	R.P.M. $=n_1\sqrt{h}$	Head	Q	Watts $=h\times Q\times 9.81/\text{eff.}$	Allowances	H.P.
.152	.....	....	....	.....	.....	....
.228	2750	23.8	20	8360	.....	....
.305	1680	23.8	20	7350	.....	....
.381	1260	23.8	20	7860	.....	....

New Electric Steel Furnace in Sheffield.—A new type of electric steel furnace, known as the Greaves-Etchells furnace, is being built by Messrs. T. H. Watson & Co. of Sheffield, England. It is suitable for making all grades of alloy steels and high-speed tool steels in small ingots. The furnace is a three-phase furnace in which two of the carbons are introduced at the top and the whole of the hearth is connected to the third phase, acting as the third electrode. With a small furnace designed to melt 6 cwts. in three hours, it has been found possible to obtain five heats of 18 per cent high-speed steel in ten hours. The longest time occupied from charging to finished ingots was 1 h. 40 min. and the shortest time 1 hr. 15 min. This small furnace has already made over 560 consecutive heats of high-speed steel and the lining has once been renewed. The standard size in which this type of furnace is being built by Messrs. T. H. Watson & Co. is for a capacity of 10/12½ cwts., but some furnaces are also being built for larger sizes, up to 6 tons.

Rubber Sponge

By Andrew H. King

Rubber sponges have been in use for quite a number of years, but until recently no one has attempted to utilize their rather peculiar properties in any other way than as a substitute for the natural sponge.

There are many methods of preparation. The time-honored practice has been to mix with the batch some material such as ammonimum carbonate, which at the temperature of vulcanization gives off considerable volume of gas, and thus causes porosity. Many different compounds have been used. Of those commonly known, two may be mentioned: U. S. Patent No. 1,103,359, July 14, 1914, to J. Huebner is for a sponge mixture consisting of 60 per cent rubber, 5 per cent rosin oil, 10 per cent zinc oxide, 10 per cent turpentine, 5 per cent sulphur, and 10 per cent ammonium carbonate. In Europe amyl-acetate finds considerable favor. A certain German sponge is said to be prepared from the following formula: 70 per cent rubber, 7 per cent sulphur, 5 per cent vermillion, 7 per cent zinc oxide, 1 per cent ceresine, and 10 per cent amyl-acetate. The actual manufacture of sponges or other articles of this material is a simple factory operation, and involves no greater difficulties than are present in every-day mold room practice.

A more modern process is that covered by German Patent No. 249,777, granted to F. Pfleumer. According to this method a soft rubber compound is cured in a mold under high pressure, using 200 to 800 atmospheres of an inert gas. This pressure is used only for the first few minutes of the cure. When it is released, the rubber is swelled to many times its normal volume, due to the contained gas. In this condition the cure is finished. The increase in volume is often as much as eighteen times normal. Because of certain mechanical difficulties, it is not possible to prepare objects of unlimited size. The inventor mentions that he has prepared cylinders up to 8 in. in diameter, and slabs 100 ft. long by 10 ft. wide by 2/10 in. thickness, by this process.

The Pfleumer method necessitates the use of very high pressures, which are always dangerous. G. Staunton, U. S. Patent No. 1,115,031, Oct. 27, 1915, uses just the opposite. He prepares a cement or dough of rubber, and subjects it to a partial vacuum, thus rendering it cellular. Vulcanization is effected by means of sulphur chloride in carbon bisulfide solution. When completely cured his product is washed with ammonia, so as to neutralize any acid.

Still another method, which seems to have great possibilities and will, no doubt, produce a grade of sponge low enough in cost to be available for many of the purposes for which pneumatic appliances are now used, is that of Schidrowitz and Goldsborough, British Patent No. 1,111, Jan. 15, 1914. The inventors operate directly on rubber latex, coagulating under conditions which yield a porous or cellular coagulum. These pores are fixed by vulcanization. The vulcanizing agent may be added prior to, during, or after coagulation, depending upon the type of article being made, and also upon the method of cure. Moreover, the vulcanization may be carried out in the wet state, and the coagulant may be such that the heat of vulcanization will bring about coagulation. In this case the sponginess is produced during the cure. It is well to mention that the coagulum need not be purified, and may be produced by use of heat, or any other common manner, as for instance: Acetic acid, organic acids which are comparatively insoluble in cold water or latex but which dissolve on heating, acid salts, carbon bisulfide, benzole, acetone, alcohol, and salicylic acid. For the production of porosity substances which generate gases when heated or by chemical action, such as carbonates, sulfides, etc., are added before, during, or after coagulation, depending upon the product desired. Vulcanization may be effected by sulfur, as such or in solution, or by compounds which liberate it. Steam is used for heating purposes.

Because of its cellular structure rubber sponge has several very peculiar properties. For example: it has the lowest apparent specific gravity of all solid bodies, being around 0.05. In spite of its cellular structure it is water tight, and very nearly gas tight. While it is honeycombed with minute cells, each cell is an individual unit and the rate of diffusion of gases through it is comparatively low. Because of its low specific gravity it has a very low specific volume, which thus brings its cost within range for common purposes. Perhaps one of the most important uses to which it has been put is in the preparation of life preservers. It will not waterlog, is light, conforms easily to the lines of the body, and is not to be ruined by a pin prick. A life raft made with rubber sponge is as near fool-proof as one can be. All sorts of floating devices, such as buoys, markers, etc., may be improved by its use.

For some time the brains and time of many men have been occupied in a search for a substitute or modification of the pneumatic tire for automobiles. We have seen about everything from metal springs to tires made with the regular tire casing but containing a solid block of gum used as a bumper. The season of tire fillers occupies now only a page in the history of this search. Springs have been discarded because of their slowness to respond, and it has been decided by the great majority of automobile owners that nothing rides as easy as air, and rather than use tire fillers they would substitute solid tires and have it done with.

Two serious objections to most tire fillers are that under constant running they tend to heat up, and finally to decompose, and second, there is quite a tendency to form flat spots.

As has been mentioned, the most satisfactory tire filler to date is air. This air is customarily held in an inner tube under moderate pressure. It is now proposed to use rubber sponge molded to fit the inside of the tire casing, and in this manner produce a puncture-proof tire. The car still rides on air, but this air is confined in innumerable little sacks. The conditions necessary for a satisfactory tire filler are as follows:

1. It must be quite stable and so constructed that fatigue is reduced to a minimum.
2. It must be light.
3. The driving power must be transmitted elastically.

Rubber sponge fulfills all these conditions. Recently Palmer tires filled with this material were driven 1950 miles with an average speed of 35 miles per hour without any apparent deterioration of the filling material.

As would be expected, the cellular nature of sponge gives it great insulating properties, both in respect to heat and sound. It is proposed to use the material for the construction of sound-proof rooms, telephone booths, under musical instruments, and under vibrating and hammering machines, etc. It is proposed also for clothing for aeronauts and Arctic explorers.

So far we have spoken only of soft rubber sponge. Hard rubber sponge is also available. It is prepared from soft rubber sponge by further vulcanization. It is understood that the soft sponge is secured by properly regulating the time and temperature of the cure. The stock is made up with sufficient sulfur to effect the transformation to ebonite, so that after producing soft rubber further vulcanization takes it over to hard sponge.

This material has an apparent specific gravity of 0.2

to 0.065, which is ½ to 1/6 that of cork, and ¼ to 1/12 that of wood. It may be worked in any way customary with hard rubber, such as sawing, boring, machining, etc. It still has the cellular structure of soft sponge, and therefore its insulating properties are not in the least effected. However, it is now not so susceptible to temperature change, and will stand temperatures up to 130 deg. C. It is recommended for ice-box walls, covering for flasks, and other insulation problems. Because of its low gravity, it has been recommended for battery jars to replace the common hard rubber jars now in use. This gives a cheaper jar, and one every bit as durable.

Hard sponge has considerable strength, and has been proposed as a material for the framework of aeroplanes. It has also been recommended as a material for constructing automobile bodies.

The Determination of Nickel in Iron Ores

By Philip Covitz

Although many investigators have studied and recommended the use of dimethyl glyoxime as a precipitant for nickel in solution by itself or with other metals, there appears to have been a decided lack of attention given to the details of all procedures in methods employing this reagent. In the hands of any but experienced chemists, unsatisfactory results have been frequent because of the failure to fully recognize and explain very important steps in the analytical process.

During a series of several hundred analyses for nickel in complex iron ores (Cuban ores containing Fe, Al, Cr, Mn, SiO_2, S and P) at the Mining Department of the Massachusetts Institute of Technology, the writer has been able to develop a procedure which, if carefully followed, will give accurate and reasonably rapid results.

The procedure is as follows:

Dissolve 1 gram of finely ground ore (100-120 mesh) in 10 c.c. HNO_3 (1.42) and 10 c.c. HCl (1.2). The quantities may be varied (preferably using more HCl) according to the nature of the ore. Always use at least 5 c.c. HNO_3 as this is essential to oxidize all reduced metals especially ferrous iron which will interfere later on. When the ore has gone into solution allow to cool somewhat and then add slowly (to avoid spattering) 10 c.c. H_2SO_4 (1.84). Boil on hot plate or over free flame cautiously until H_2SO_4 fumes come off freely. As the solution becomes concentrated, it will gradually turn green, basic sulphates will separate out as a white sludge and violent bumping and subsequent loss by spattering will result unless care is taken to control the heat. The H_2SO_4 is added to drive off the HNO_3 whose presence is injurious at a later stage in the process.

After the contents of the container have been brought to copious fuming, they should be cooled and then 30 c.c. water slowly added, agitating or stirring in the meanwhile. The addition of water to the concentrated H_2SO_4 in solution will cause considerable evolution of heat so that caution must be observed in such addition, else violent ebullition and ejection of contents may occur.

Add 2 or 3 c.c. HCl (to aid in solution of soluble salts) and heat 10 to 15 minutes on hot plate or until salts have dissolved. Put in 5 grams citric or tartaric acid (to prevent precipitation of trivalent metals), and when dissolved filter into a 300 c.c. beaker. The importance of driving off HNO_3 by the addition of H_2SO_4 will be recognized on adding the citric acid. If HNO_3 is present, it will react with the citric, decomposing the latter. This reaction will be indicated by the rapid evolution of the gas (probably CO_2) and will interfere with subsequent precipitation of nickel.

Wash the filter thoroughly with hot water and dilute the filtrate to 100-125 c.c.

Now carefully neutralize the filtrate by adding NH_4OH slowly, stirring thoroughly until a drop of solution just turns red litmus paper blue, then make faintly acid with HCl. This part of the procedure is very important and must be given special attention. As the NH_4OH is added, there will be a change from a pale green to a brownish color, which latter will suddenly change to dark green just before the neutral point is reached. This green should persist even past the neutral point. If a slight excess of NH_4OH beyond the neutral point produces a dark brown color, not enough citric acid has been used. In such a case slightly acidify the solution with HCl and add enough more citric acid to produce the desired green color, the lighter the green the better.

Having made the filtrate slightly acid, heat to 70-85 deg. C., add slowly and with constant stirring 20 c.c. of an alcoholic solution of dimethyl glyoxime (which has been prepared by dissolving 8 grams dimethyl glyoxime in 1 liter of ethyl alcohol) and just enough NH_4OH to form a precipitate. A very convenient stirring rod may be made by using a thermometer, protecting the mercury bulb by a small band of rubber tubing about ⅛ in wide, placed on the very tip end. This serves as a combination stirring rod and thermometer.

Care must be taken to avoid an excess of NH_4OH, as this tends to prevent the formation of the nickel precipitate.

Heat the solution until the alcohol begins to boil off. Remove from hot plate and allow to stand a minute or so when the precipitate will coagulate readily. Filter on a weighed Gooch crucible, wash with hot water and dry at 110 deg. C. for forty-five minutes. Weigh and multiply by 20.31 to get the percentage of nickel in the sample.

The precipitate should be red and crystalline, while the filtrate should be amber yellow to yellowish green and clear.

If a large excess of NH_4OH has been added, the filtrate will be dark, sometimes brown, and not transparent. In such a case the excess of NH_4OH has probably caused a precipitation of ferric hydroxide. This will, of course, give high results due to filtering off of ferric hydroxide along with the nickel precipitate. The latter will be brownish in color and should be discarded. If directions are followed, however, this will not occur.

There have been times when the writer was troubled with a blood red filtrate from the nickel precipitate. This was shown to be due to the presence of ferrous iron. The red color indicates dissolved nickel. If such a condition occurs it shows that not enough HNO_3 has been used, and that oxidation of oxidizable matter has been incomplete. This may be remedied by slightly acidifying the filtrate from nickel precipitate, boiling with 10 c.c. of bromine water and precipitating formerly dissolved nickel by addition of NH_4OH in very slight excess, filtering and adding the precipitate to that first obtained.

The method in brief then is: Dissolve 1 gram of ore in 10 c.c. HCl (1.2) + 10 c.c. HNO_3 (1.42). Cool, add 10 c.c. H_2SO_4 (1.84) and evaporate carefully until H_2SO_4 fumes copiously. Cool, then add cautiously 30 c.c. water, agitating meanwhile. Add 2 to 3 c.c. HCl, heat ten to fifteen minutes, and filter into 300 c.c. beaker. Dilute filtrate to 125 c.c., neutralize with NH_4OH. If on passing the neutral point the color of the solution is brown, add enough citric acid to bring to desired green. Add few drops HCl (enough to make barely acid). Heat to 70-85 deg. C., add 20 c.c. glyoxime solution, stirring constantly, and allow solution to come to boil. Let stand for minute or two, filter on weighed gooch, and dry in oven at 110 deg. C. for forty-five minutes, cool and weigh.

20.31 per cent of precipitate is nickel.

The precipitate may be removed by use of hot HCl or HNO_3, in which it is soluble.

Since the completion of the writer's work there has appeared in the September number of the *Journal of Industrial and Engineering Chemistry* an article by G. L. Kelley and J. B. Conant of the research department of the Midvale Steel Company of Philadelphia, on the "Use of Diphenyl Glyoxime as an Indicator in the Volumetric Determination of Nickel by Frevert's Method." This article is interesting because of the fact that nickel is first removed from solution by precipitation with dimethyl gloyxime, the precipitate dissolved in acid and then the nickel determined volumetrically. Kelley and Conant, however, recommend the use of an ammoniacal solution of glyoxime instead of the alcoholic solution used by the writer, and also precipitation of the nickel in an ice cooled solution.

In view of the fact that excess of NH_4OH is detrimental to the accuracy of the process, it would appear that the use of the ammoniacal solution of glyoxime would be highly undesirable because of the great danger of introducing an excess of NH_4OH by its use. Again the precipitation of nickel dimethyl glyoxime in the cold is quite unsatisfactory, for not only is the precipitation very slow (Kelley and Conant advise one hour's standing), but the precipitate itself is not as crystalline or easy to filter as is the case when higher temperatures are the rule. The formation of a precipitate at 70 deg. or over is almost instantaneous.

To sum up then, the determination of nickel by the method given is accurate, reasonably rapid and will give good results even in the hands of an inexperienced analyst. It has the further advantage of obviating the necessity of removing other elements, citric acid serving to take care of iron and other metals present. The writer feels that while the volumetric method of H. L. Frevert (Blair's Chemical Analysis of Iron, 7th Ed., 1912) may be more rapid, it is not as accurate or as satisfactory, and certainly in the hands of the average analyst not as simple of operation and as productive of results as is the gravimetric method herein described.

Massachusetts Institute of Technology.

The Chemical and Physical Properties of Foundry Irons

By J. E. Johnson, Jr.

(*Concluded from page* 646)

Principal Varieties of Foundry Irons and Their Composition

Foundry irons may be divided according to the kind of castings made into four classes, as follows:

Machinery and general castings, chilled castings, malleable castings and heat-resisting castings, especially ingot molds.

Machinery and General Castings

The range of these is very wide and the specifications for the iron used in making them vary accordingly. It is only possible to cover the subject in a broad general way.

SILICON

The silicon in machinery castings may be said to vary from 1¼ or 1½ per cent in large heavy castings up to 3 or 3¼ per cent in very small light castings.

SULPHUR

Sulphur in iron machinery and general castings is almost always an unmitigated evil. It is sometimes used to close up the grain of the iron, but this causes a simultaneous hardening of the surface of the casting, particularly sharp corners and edges, which are quickly chilled. This greatly increases the difficulty of machining such castings, and the use of sulphur for this purpose is never justifiable.

Sulphur is always added to the iron when it is remelted in a cupola for casting, the amount so added varying from 0.03 per cent in the best cupola practice up to 0.10 per cent or even more in the worst and averaging around 0.05 per cent in ordinary good practice. As the sulphur in good castings should be below 0.08, or certainly below 0.09 per cent, it is evident that the sulphur in the iron must be kept under 0.05, and preferably under 0.04 per cent, and these are the ordinary specifications for foundry iron.

PHOSPHORUS

Phosphorus was formerly considered to be a detriment to foundry castings and it was considered desirable to keep it as low as possible, or at least below 0.3 per cent, but we know now that phosphorus imparts fluidity to the metal and also increases the strength up to certain limits so that in machinery castings phosphorus commonly runs from 0.04 to 0.75 per cent. In some specially thin castings, such as stove plate, it runs higher even—up to 1 per cent in order to obtain the fluidity necessary to pour these thin shapes, while in automobile cylinders, as noted earlier, it is necessary to keep the phosphorus under 0.3 per cent in order to prevent spongy spots in the castings. In the ordinary run of machinery castings, however, the phosphorus ranges within the limits given.

MANGANESE

Manganese specifications for foundry iron vary between extreme limits. In some cases as much as 2 per cent is desired for special reasons, while in other cases the least amount possible is desired, but these extreme specifications are for special cases and manganese in the iron for ordinary machinery and general castings runs from about 0.6 to 1.0 per cent.

CARBON

No attention is paid to the carbon in ordinary machinery castings except where special strength is desired and then the carbon is lowered by adding steel scrap to the cupola charge; this constitutes the so-called semi-steel.

OXYGEN (IN MACHINERY CASTINGS)

The relation shown in the previous chapter between oxygen content and strength of castings indicates clearly that when strong close grained and dense casting are desired, an iron high in oxygen should be used. When a mixture of irons is introduced into the cupola, it is easier to obtain the desired amount of oxygen in the cupola iron by the introduction of most of the oxygen with that portion of the mixture containing the least manganese primarily and the lowest silicon secondarily. As to the absolute quantities of oxygen desirable, we have not as yet sufficient information on which to base exact specifications. Iron with 0.06 oxygen is 50 to 75 per cent stronger than ordinary coke iron without oxygen, and this strength persists when the iron is remelted in the cupola. The kind of castings desired must control the relative importance to be given to oxygen and the other elements. As a general thing, the strength imparted by a given percentage of an oxygen bearing iron is more proportional to the percentage of that iron added.

Chilled Castings

SILICON

Silicon is the element which has the maximum effect in promoting the separation of the carbon from its original combined form into graphite, and as the production of chilled castings consists in keeping the carbon combined with the iron, the silicon must accordingly be low. For car wheels, the principal purpose for which chilled castings are used, the silicon is desired about 0.75 per cent. For other purposes, it falls as low as 0.25 per cent, and for still others rises as high as 1.25 per cent.

SULPHUR

For some kinds of chilled castings where great hardness without much strength is desired, iron with sulphur running up to 0.2 or even 0.3 per cent is sometimes used as an ingredient of the cupola charge, and in some car wheel foundries the regular practice is to make car wheels containing 0.18 or 0.19 per cent sulphur, but this is exceptional and in my judgment bad practice. The chill of the castings should be obtained by lowering the silicon rather than by raising the sulphur except within very moderate limits. In chilling irons made with coke, sulphur is commonly accepted up to about 0.1 per cent.

PHOSPHORUS

Phosphorus in chilled material commonly varies between 0.25 and 0.7 per cent. The phosphorus in the iron for this material ordinarily lies within the same limits. For car wheel purposes phosphorus is not desired above 0.35 per cent.

MANGANESE

Extraordinary latitude is used in manganese specifications for chilled materials. Some consumers want the manganese down to a trace while others specify manganese up to 2 per cent. The reason for this appeared earlier and need not be repeated here. In the ordinary run of chilled castings, manganese ranges between 0.4 and 0.8 per cent.

OXYGEN

In the foregoing chapter it has been shown that oxygen exercises a greater influence on the chilling power of an iron than any other element except silicon. When chilled castings are to be made, it is not desirable to obtain the chill desired by lowering the silicon or raising the sulphur beyond certain limits because of the brittle crystalline chill which these extremes cause. By the presence of oxygen in the iron, we can obtain the desired amount of chill without a very low silicon and in the almost complete absence of sulphur.

Sulphur is the element which causes the greatest degree of brittleness in chilled castings, especially car wheels, and its detrimental effects must be reduced by increasing the manganese which in turn has a very undesirable effect on the properties of the chill. For this reason the best chilled castings will come in time to be made of irons low in sulphur with a moderate amount of silicon, high in oxygen and low in manganese.

CARBON

It is in the field of chilled castings that the most attention is paid to the quantity of carbon present in the iron. The reasons for this are numerous and complicated as have appeared earlier, so they do not need to be given here.

Suffice it to say that for some chilled castings the carbon is desired well below 3 per cent, while for many other purposes chilled castings have proven of inferior quality because they did not contain a sufficient amount of carbon to give them the hardness desired. It is probable that the maximum amount which can be used satisfactorily is about 4 per cent.

When the carbon rises much above this point, another set of influences come into play which are likely to destroy rather than to augment the hardening action. In chilled rolls much lower carbon is required, but this, as explained in connection with hyper-eutectic irons, is obtained by mixing steel scrap with the charge or by oxidizing part of the carbon in the air furnace.

Malleable Castings

Malleable castings in American parlance are castings which are solid white when cast and then have their carbon converted into graphite by annealing at a high temperature. Such castings can be bent cold and have a considerable amount of toughness. When subjected to a tension test they show a decided elongation and reduction of area which are not shown at all by ordinary casting iron, hence the name malleable castings.

In order to meet the condition that the castings must be white when made, the silicon must be kept comparatively low, ranging from about 1 per cent for large, heavy castings to about 1.75 per cent with small castings of light section. More or less of this is oxidized out in the air furnace, in which the iron for these castings is generally melted.

SULPHUR

Sulphur is very objectionable in the malleable process because it tends to prevent the breaking down of the carbon into graphite, which is the essence of the process. Iron for malleable castings is generally melted. The absorption of sulphur in the air furnace is very much lower than in a cupola, but in spite of this the sulphur specifications for iron for malleable castings are as severe as those for ordinary foundry iron, sometimes even more so. For most purposes the sulphur is held below 0.05 per cent and it is usually desired below 0.04 per cent.

PHOSPHORUS

The specifications for this element are much closer in the case of malleable castings than in most others. If the phosphorus be too low, the metal has not sufficient fluidity, and if it be too high, the metal is brittle and unreliable when annealed. The phosphorus is, therefore, very generally kept between 0.12 and 0.25 per cent.

MANGANESE

The practice in regard to manganese varies in this department of the industry almost as much as in chilling irons, some manufacturers desiring it high and others low. The probabilities are that manganese should be between 0.3 and 0.6 per cent for best results.

CARBON

The conditions in regard to carbon are very much the same in malleable castings as they are in chilled castings, although the limits through which it is made to vary are not so wide. Some manufacturers will pay a premium for iron with carbon well under 3 per cent, while others accept the carbon as it comes from the furnace without comment. It is my impression that no commercial iron ever contains as little as 3 per cent carbon when it comes from the blast furnace, and this element can only be reduced to these low limits by treatment outside the furnace.

OXYGEN

It has been definitely ascertained that the presence of oxygen is highly beneficial in chilled rolls melted in the air furnace. The practice in this branch of industry is very similar to that in the malleable industry, and taken

in conjunction with the fact that the best malleable is made with charcoal iron, it is probable that oxygen is highly desirable in malleable castings. The fact that its presence tends to throw the carbon into the combined condition in the presence of even considerable percentages of silicon, indicates also that the presence of oxygen is desirable in this branch of the foundry industry.

Ingot Moulds and Heat Resisting Castings

In order to resist the expansion and contraction strains brought about by the frequent changes of temperature, iron must have a loose and open structure. The graphite must be in large flakes so that the individual grains of iron can hinge on one another, sliding and bending on the soft graphite. Anything which tends to close up the grain of the iron and reduce the area of the graphite flakes by coagulating them into nodular particles, reduces their ability to act as hinges, and therefore makes the iron more rigid. This means that being unable to bend under the stresses brought about by contraction and expansion, when exposed alternately to heat and cold it soon breaks. Our object, therefore, must be to produce the most graphitic iron.

SILICON

For reasons which were explained at least in part earlier, the maximum amount of carbon is taken up by iron containing about 1 to 1½ per cent silicon. Therefore, the silicon in ingot molds is always kept within these limits.

PHOSPHORUS

Experience has proven that phosphorus exercises a vital influence on the life of ingot molds. Molds made from iron containing more than 0.08 per cent phosphorus (the Bessemer limit) fall off rapidly in the number of heats they give in service. The reason for this is not fully understood, but it is probably due to the effect of phosphorus in hardening the iron and closing up its grain, as described earlier. For this reason the phosphorus specifications for ingot molds are very severe and it is in all cases kept as low as commercial considerations will permit, always within the Bessemer limit.

MANGANESE

As was shown earlier, there is a certain quantity of manganese which makes the softest iron. An amount either smaller or larger than this will make the iron harder. This amount is roughly from 0.4 to 0.8 per cent, and it is within these limits that the manganese in ingot molds should be kept. If it rises, the silicon must be raised to offset its hardening influence on the iron.

SULPHUR

In order to have the iron as soft and graphitic as possible, it is necessary that the sulphur be kept to the lowest possible limits, and this is always done in practice. Conditions in this respect are greatly bettered by the fact that ingot molds are usually cast from direct metal, that is, metal taken directly from the blast furnace, not cast and remelted as is done with practically all other kinds of castings. There is no doubt the lower the sulphur is kept the better, and it should be always under 0.05 per cent to secure the best results.

CARBON

The carbon in the ingot molds should be as high as possible to promote the greatest possible formation of graphite in accordance with the laws controlling its action already explained. This, however, is a matter whose control is subordinate to that of the other elements, and is accordingly ignored in practice.

OXYGEN

Recent investigations have proven that this element exercises the most powerful influence of any, except, perhaps, silicon, upon the life of ingot molds. It has been shown how powerful is its influence in coagulating the graphite, and it has been found in practice that ingot molds made from iron relatively high in oxygen give only a fraction of the life of those made from an iron of identical analysis except low in oxygen. This is not generally known, but has been proven in practice in the most indisputable way. For this reason, the quantity of oxygen in the iron should be a primary consideration, and to reduce this it may even be justifiable to raise the manganese. If the oxygen cannot be reduced in the furnace to sufficiently low limits, it should receive a treatment outside the furnace in order to bring about this result.

Grading in the Cement, Coal and Cork Industries

By Edward S. Wiard

Cement

For the manufacture of this material a mixture of an aluminous and limy nature is needed. In the Lehigh district these exist side by side. In some properties in this district the proportion of shale and limestone occurs almost in the proper proportion and correction of the mixture of the two constituents is called for rather than proportioning (Fig. 1). After proportioning, the constituents of the cement are burned almost universally in long revolving calciners heated by a coal dust flame. The resulting clinker is reduced by rolls and mills, the Griffin type being popular, and following this the final reduction is made in tube mills on leaving which machine 80 to 85 per cent of the cement will pass a 200 mesh screen.

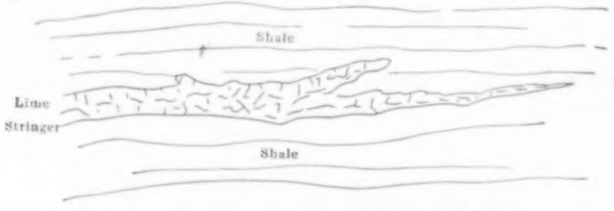


FIG. 1—SHALE AND LIMESTONE DEPOSITS

At the eastern plants cement has been sold as low as $0.65 per bbl., the cost of production ranging from $0.40 to $0.55. The production of Portland cement in the United States has risen from nothing in 1890 to over 25,000,000 bbl. at the present day, of which the Lehigh district produces in the neighborhood of 30 per cent. The average price for the whole country has fallen from $3.00 a bbl. in 1890 at the works to about $1.00 a bbl. at the present. In the western states the price is as high as $1.50 per bbl. at the works.

Cementitious quality resides entirely in the finer particles of the cement. A good Portland cement should show at least 92 per cent through a 100 mesh sieve and 75 per cent through a 200 mesh sieve. This test is, however, merely a relative measure, for of two cements complying with it one might be superior to the other through having a much greater amount of very fine material. If a closed circuit were established below the tube mill, all material over a certain size being returned to the tube mill, the ensuing product would undoubtedly be more valuable, but it is a question whether, with fixed test conditions such as exist today, the superior cement, with its greater cost, would find a general sale. Again

the proper machine to effect the separation has not been devised, although the McKesson belt machine described in an earlier article of this series on the grading industries or something similar may be applicable.

There have been some tests performed to show the better cementitious quality of the finer part of cement, but they have not been conclusive, merely showing in a qualtitative way that as the fineness is increased a better result is secured.

Coal

Anthracite coal is graded into the following sizes:

Size	Through	Over
Broken or grate	4-inch square	2¾-inch square
Egg	2¾-inch square	2-inch square
Stove	2-inch square	1⅜-inch square
Chestnut	1⅜-inch square	⅝-inch square
Pea	¾-inch square	½-inch square
Buckwheat No. 1	½-inch square	¼-inch square
Buckwheat No. 2 or rice	¼-inch square	⅛-inch square
Buckwheat No. 3 or barley	⅛-inch square	1/16-inch round

The last three sizes are used for steam raising in competition with soft coal and are never sold for domestic purposes. The cost and difficulty of grading below ⅛ inch and of separating the slate or other impurity from the coal is very great.

The very fine coal goes to the culm pile or returns to the mine for filling. There would be a large reward for inventors who were capable of treating economically this material and delivering it free from impurity and fines.

The number of sizes of coal made with soft coal varies according to locality. There is not much done in this respect. In the east soft coal is seldom graded, being used just as it is broken down and run out from the mine. In the west, where, except for the small patches of anthracite in Colorado and elsewhere, the coal is all soft, it is graded for domestic sizes, but this rarely extends to offering the purchaser more than run of mine lump or nut size. The lump being the nut and slack removed, the latter being sold separately.

Practically all types of screen are used in coal mining. Owing to the greater breakage, flat screens are preferred to revolving, but the latter are used to a great extent. Stationary and shaking grizzlies are the preferred flat screen. The Cox and shaking grizzly described under the technology of screening has an extensive use in the Pennsylvania field. The requirements for a coal screen are capacity, medium quality of work, and freedom from coal breakage.

In addition to the ordinary types of flat screens revolving disc screens are used and give positive advance and great freedom from breakage. Devices of this kind are, of course, only permissible for the coarse grades.

In addition to the ordinary inclined stationary grizzlies, consisting of bars held together with washers, various forms of screens with wavy surface are used, the effect of which is to stir up the mass being fed, and to give the undersizes a chance to get through the apertures. George W. Cross has had a multitude of patents bearing on screens of this character, for further information concerning which reference should be made to the patent files. For the fine sizes shaking screens are preferred.

In the anthracite and western washeries all the different types of screen are employed, and this applies to washeries treating the mine product as well as those retreating culm banks.

The earliest mention of coal in the United States is recorded in the journal of Father Louis Hennepin under the date of 1679; he mentioned the site of a "cole" mine as on Illinois River, near the present city of Ottawa. In a report to the Virginia Assembly in 1701 mention is made of a discovery of coal in the Richmond Basin near Richmond, Virginia. The first mining of coal was from this locality between 1720 and 1750. Coal was discovered in Ohio in 1755, but production did not begin on a commercial scale until 1838. Coal mining in the leading coal state of Pennsylvania began in the bituminous field in 1760, the first discovery being near Fort Pitt, or Pittsburgh. The first discovery of anthracite in Pennsylvania was in 1762. Commercial mining began near Pittston in 1775. It was not until nearly thirty years later that coal began to be mined in the Schuylkill district of the anthracite field. From 1807 to 1808 the shipments from the Wyoming district alone had reached a tonnage of 12,000 tons, and the anthracite coal business was well established. (For further historical notes see Mineral Resources of the United States, 1913.)

Cork

The cork tree is a species of oak (Quercus Ilex, better known as Quercus Suber), and the outer bark, which is the commercial cork or wood, is first harvested when the tree has a circumference of about 16 inches and thereafter regularly every nine or ten years throughout the life of the tree. The best bark commercially is obtained when the tree is over five years old. Stripping does not injure the tree and makes the formation of a new bark more rapid than that of its predecessor. The bark is cut from the tree by encircling cuts at top and bottom and these must be carefully made so as not to injure the tree. Following this a longitudinal cut is made and the bark pried off with wooden wedges. Bark can also be removed from the branches of the larger trees provided it is at least a half inch thick.

The bark from the trunk of the tree attains a thickness of 2 inches or more and the yield from a single tree at one cutting may be as high as 500 lb. or as low as 50 lb. After a few days drying following the stripping the bark is boiled to make it soft and flexible and to make easy the scraping off of the woody outer coating. It is then baled for shipment, after being graded for thickness and quality.

The part of the cork which faces the tree is called the belly and is reckoned as one-eighth inch thick. The outer layer also reckons as one-eighth inch thickness and is called the outside. The part between these two layers is called the thickness and ranges in depth from one-half to three or four inches.

All cork wood comes from Andalusia, in Spain, the principal shipping ports being Barcelona and Seville. Practically all the cork is exported, but of late years there has been some attempt to manufacture cork products in Spain.

Most of the bark is first cut up for stopples, which in times past used to be done by hand labor, and that method is still practised in Spain. By this method the cork boards had to be cut into strips, after sorting into a great number of grades according to thickness and quality. The width of any cork stopple is limited by the thickness of the cork, for the latter is cut into strips longitudinally and the stopples cut from the strips cannot attain a greater diameter than the thickness of the bark. Where cutting by hand is in practice the strips are cut up into squares and whittled to the proper shape and finished by sandpapering. By this method there is, of course, great waste, for the chips which result are not entirely suited to other uses for which granulated cork may be used. One by-product of the cork manufacturing industry in Spain is the cork powder in which grapes have been packed in the past. California grapes are now packed in redwood sawdust, which has been found to be an efficient substitute.

The whole range of manufactured cork products is produced in the United States. The procedure at one plant for producing stopples will serve for all. The bales are received from Spain containing slabs approximately 4 feet long and 18 inches wide. A bale weighs from

160 to 200 lb. The grade of the cork depends first on the thickness, as the thicker the cork the higher the price it commands. Second on the proportion of solid, smooth fiber, free from channels, cracks or other air passages. The cork costs on an average 12 cents a pound at New York and 12½ cents at Chicago (these are pre-war figures).

The slabs are first steamed and then cut up into long strips, as is done in the hand process. While still warm and plastic the strips are passed through a machine which punches out a single row of blanks. If the bark be unusually thick or the cork blanks small then two rows can be punched at one time. The blanks are then passed to a tapering machine. After this they are sandpapered and disinfected and are then ready for the market.

While the making of stopples is an important industry the bulk of the output of the factories has to do with cork products made from the waste of the cork strips.

In the manufacture of cork board and insulating material the waste from stopple factories on fresh cork board is ground up in revolving disintegrators. Following the disintegration it is screened on gyrating bolters and made into cork powders for heat insulation cork board or tread-cork inner soles for shoes, etc. Cork board is either put together with a tarry bond under heat and pressure or its own oils will furnish a bond under heat and pressure. The screen sizes made by the different manufacturers vary according to their personal notion as to what is proper in this respect and the varying demands of the trade. At one of the factories visited they were using the following sets of screen in the bolters: 3/8, 5/16, 1/4, 3/16, 1/8, 3/32, 1/16, 1/24, 32 mesh, 36 mesh. The undersize of the last screen has a use for linoleum making if sufficiently pure.

In the grinding of the cork the greater proportion of the woody outer layers which cannot be removed by scraping or which would entail too great a loss of good cork if cut away, grinds up more rapidly than the true cork, which is very resistant and forms shreds rather than granules, the woody portion consequently appears in larger proportion in the finer sizes.

This contaminated material is one of the problems of the graded cork industry. At one of the factories middlings purifiers such as are used in the flour mills are employed to effect a separation. When used for cork the latter is, of course, the product which is raised by the air current and carried to the separator. At another of the cork plants some tests were made with the Sutton-Steele table with quite a considerable degree of success.

Quite frequently the cork from the fine sizes is so impure that it must be thrown away. Revolving screens cannot be used for grading cork with any degree of success because of the buoyant effect of air currents which are set up by the motion of the screen. Reciprocating screens are not favored for the same reason, to a lesser degree and for the additional reason that the motion of such screens is too violent and keeps the mass of cork in too agitated a condition without sufficient contact with the screen.

Cork crushers are shredders and break up the cork by tearing it to pieces. Cork screening considered from the point of absolute size is very unsatisfactory, the cork shreds of any size comprising particles which may readily be compressed to a smaller compass or from which fragments of loosened cork may readily be detached.

The process of making linoleum was invented by Frederick Walton in England in 1860 and the product was first brought out under the name of Kamptulicon, but later received the name linoleum. The foundation of linoleum is jute burlap. For manufacturing linoleum the very best grade of cork must be used and ground very fine in a buhr mill. As in flour milling, care must be taken that the dust arising from the grinding operation does not become so excessive as to cause liability to dust explosions.

The bonding material for the cork powder is what is known in the trade as cement. For this purpose linseed or other drying oils are used, these being oils which on exposure to the air will absorb sufficient oxygen to form a solid resinous mass. The linseed oil must be of good quality. The oil is first boiled, as in paint making, and the process of drying is facilitated by adding a small quantity of oxide of lead. From the boiling tanks the oil passes to pieces of light cotton fabric known as scrim, which hang vertically from iron bars. The oil is poured over the scrim and what adheres to the surface at a temperature of about 100° F becomes hardened. This operation is repeated from time to time until there is a coating on the scrim of sufficient thickness, when it is cut down and ground between rollers. The usual thickness of the skin on the scrim is one-half inch. The ground oil is then mixed with resin and kauri gum until the whole mass is homogeneous and forms the cement.

The cement and cork are then mixed together, and if the linoleum is to be plain the coloring matter is added at this stage. The mixture is then rolled onto the jute burlap backing, there being two cylinders to effect this operation and secure evenness of the layer. The printing of the design is done by machinery. Rising and falling color blocks are used, this motion aiding the repetition of the design. Each set of blocks have their own color and all the different colors have to be printed before the design is complete. The movement of the linoleum under the printing blocks is continuous.

In the manufacture of inlaid linoleum the mixture of cement and cork is compressed into sheets of different colors which are afterwards cut up into the components of the design and are affixed to the burlap by pressure. In another process the linoleum mixture in the form of a powder is dropped upon the jute in a way to make the design and is then subjected to heavy pressure to fix it and secure a permanent contact with the backing.

Science and Industry*

By J. Swinburne

A lecturer on this subject is expected to discuss the dependence of industry on mathematics, physics, chemistry, bacteriology, botany, and to a less extent a few other branches of science, such as biology, geology, and astronomy, and he is expected to show how the universities can help the industries of this country in two directions. The first is training men in the different branches of science, so that they can go into industrial work and be of the greatest value; the second is helping manufacturers directly by the advice of university professors and by carrying out technical research at college laboratories.

Coal mining involves some geological knowledge. Burning coal to get heat is applied chemistry. It is generally misapplied chemistry, because furnaces are usually not designed to give the mixed heated gases time to finish their reactions before the heat is taken from them. But, much more important than this, in burning raw coal we are wasting products which are daily becoming more valuable. The ordinary house fire, for example, is a barbarous apology for a heating device. Navigation depends on astronomy; metallurgy is a

*Lecture delivered at King's College (University of London) on Nov. 8, and forming one of a series which will be published by the College in due course. From the London *Electrician*.

branch of applied chemistry; the design of good steam, gas and oil engines demands a competent knowledge of applied thermodynamics. All machinery embodies applied mechanics. In many cases, such as metallurgy, mechanics, the steam engine and the sailing ship, the application preceded the science; but in most modern developments, as, for instance, electrical engineering and fine chemicals, the industry has followed the science, helping in its turn, so that they continue to develop together.

Many branches of industry are the direct application of scientific knowledge or discovery, made without any idea of its practical value. The foundation principle of wireless telegraphy is a good example of this. Again, few students of Routh's rigid dynamics would have thought of making a gyrostat serve as a compass. Problems of capillarity seemed to have only scientific interest, yet Elmore's process for the separation of complex ores and its various modifications which have been worth hundreds of thousands to those concerned—except the inventor—depends on differences of surface tensions. In short, every industry in the country has its technology, or applied science, and the better this is understood by those in charge the better it is for the industry and for the country.

It is not my duty to discuss science as the root, or even a branch of education in itself. I am not an expert in education. I do not understand why education is as it is, or what it is meant to do. It seems to be like virtue, its own reward, without any ulterior advantage. To my non-expert mind, education ought to have four main objects. First, to enable one to earn his living, because if he cannot make his living nothing else is much use. Second, to let one know enough about his health to secure it. It is no use making a living or anything else if, owing to your own ignorance, your health is wrecked and you are prematurely buried. Third, to make one a good citizen. Fourth, to enable one to enjoy his well-earned leisure properly. These principles appear to be wrong, for they do not in the least fit education as commonly inflicted.

All the same, I will assume that under the first head there is a question of university teaching of science, with the object of its connection with industry. The main question is, then, How can universities best fit students to make their living by science in industry? To make the discussion complete, we ought also to discuss the question, How can business men make the best use of universities and of the men trained by them? This last question need not be discussed here, except in so far as the attitude of business men must react on universities attempting to work in conjunction with them.

In discussing its relation to industry, we must understand what we mean by science. Mathematics is the science of quantities and their relations. There are pure and applied mathematics. Pure mathematics is a study by itself. Kelvin called it the quintessence of common sense. The pure mathematician has one part of his brain very highly trained in one direction, and he has a remarkable mental acquirement and a special kind of knowledge and ability; but in a sense he is of no use, and pure mathematics is of no use. Mathematics may be applied to solve problems in astronomy, physics, mechanics, chemistry and statistics. To one devoted to pure mathematics this is a kind of debasement of his subject, and he is apt to look down upon people who use mathematics for such low purposes. The pure mathematician works strenuously, extending the bounds of his subject, and develops a new theorem or invents a new calculus. The astronomer or the physicist follows his work, and utilizes his advances to attack his own problems by applying them. We thus have pure mathematics and applied mathematics. Sometimes the same man—Newton, for example—makes advances in both pure and applied mathematics.

In science generally we have the same distinction. Science itself is a complicated fabric of organized knowledge of Nature. The man of science devotes his life to extend this fabric of knowledge in new directions, and perhaps even more to elucidating the relations of the various elements, the object being to make the wonderful fabric complete in all its parts, with their interdependence, as far as it can be, clear to the limits of the mind. In a sense this is of no use; but surely it is the noblest exercise of the human intellect. This is called pure, as opposed to applied, science, because it has no direct ulterior purpose. The term is bad, as pure and applied are not opposed, and all kinds of science are quite pure. Theoretical has been proposed, but in the popular mind theoretical is opposed to practical, while to the technologist nothing is practical unless it is theoretically right. I will, therefore, use the word academic to specify science pursued as an end in itself, without any regard to any external or ulterior use, the object of the pursuit being the attainment of knowledge and the development of the intellect. The word also fits as this kind of science is developed mainly by teachers.

Nearly all great advance in academic science is, and has been, made by professors in universities and colleges and their assistants—or, in short, by teachers. It might be supposed that a body undertaking the education of young men would choose the man best able to explain matters to students. This is not the practice, however. A university gets the most eminent scientific man available, or chooses a young man who promises to become eminent. He is given every assistance to make himself as famous as possible as a scientific discoverer, and apparently scientific distinction is his sole aim, the education of the students being of no account. This curious arrangement seems to work splendidly. It secures men of great ability, and they do good work, which would hardly be done otherwise at all; and instead of the students being neglected, they get fired with their leader's enthusiasm, and become assistants and coworkers, and eventually carry on the great work themselves.

We have thus academic science; we also have utilized science or technology. The technologist, as such, is not interested in the fabric of organized Nature knowledge or academic science. He takes bits of the knowledge and uses them in manufacture. Sometimes the technologist is first, and his work is fitted into its place in academic science afterwards. Academic science generally develops it, so that the technologist is helped further forward. The technologist generally studies the branches of science which concern him till he knows more about them than those who have the more balanced knowledge of academic science. But this is not all: he has to look at matters from a different standpoint. He has always to consider prices and costs. He has to make his works pay. An engineer is one who makes for $1 what any fool can make for two. This obviously American definition, of course, covers the chemical manufacturer, and, in fact, every other manufacturer.

Academic science thus does not cover technology. The knowledge is not there in the right form, and it is not in the right proportion, and it is entirely independent of all questions of cost, which are fundamental in technology. Here we have the great difficulty. The science teacher and the general public confuse academic science and technology, and think that the science taught at school or at the university is what is wanted in industry. This is a serious mistake. The teacher especially

is apt to assume that academic science includes technology. It has been suggested that Faraday could have made a fortune by devoting his abilities to industry. He was about as well fitted for success on the turf. It is often said that this or that eminent professor could have made untold wealth if he had stooped so low, but he preferred to labor for a higher object. Of course, this is all nonsense; all men work in competition for the approval of their fellow creatures. Some like to earn it by advertisement and other easy methods, but the student of science is satisfied to earn it only by intellectual effort, but all the same that is his real motive. The case of Cavendish is difficult to understand; but, speaking broadly, fame is the reward sought by the man of science, though he does not say so as naively as the poet.

The idea that academic science includes technology does harm in several ways. It prevents the science teacher understanding technology or realizing what the manufacturer wants. It leads to his looking down on manufacturers as ignorant people, because they have not his particular kind of knowledge. The standpoint that academic science is all important and technology something outside it and quite inferior is, as far as I understand the position in France, the French Academy view. The standpoint that academic science includes technology, or renders any special knowledge of technology unnecessary, is the Royal Society point of view. A few technologists are fellows of the Royal Society, but it is essentially a non-technical society, and much harm is done by its being put forward to deal with technical or industrial matters. There are technologists among the fellows, but the society is essentially untechnical. There are good technical men at the Bar, but it would be absurd for the Government to apply to the Bar Council for scientific advice. It is not true that industry is unscientific either in France or in England, but it will be much better when they get rid of the Academy attitude over there and we get beyond the Royal Society view.

The question is, What ought universities to do? The obvious answer is that they should drop academic science and cultivate only technology. When a course seems quite obvious, and is not at once followed by competent people, it is generally wrong. If we dropped academic science we would drop technology, too, and lose all. Academic science depends almost entirely on universities, and great technological advance is possible only in conjunction with academic progress. In fact, it is like happiness: you can only get it by striving for something else. The universities of the country cultivate virtue in the form of academic science, and the country gets happiness in the form of industrial success. But while cultivating virtue it is foolish to despise any happiness that may come along as an indirect result.

The spirit of academic science does not necessarily render a man less useful as a technologist. Quite the reverse. As long as it does not lead him to look down on technology or to think he knows all about it without any special study it helps him.

Whether it is possible to teach technology satisfactorily in college courses is an open question. A professor of academic science can be in the van of his subject, as he is himself taking part in it. A professor of any branch of technology must be behind his subject, as he has to learn from what is going on in works, which in many cases are not open to him at all. No commercial works wants college professors loose in them, attempting to keep up to date in practical matters. All he could hope to teach satisfactorily would be such matter as can be found in text books, the text books being written generally by other teachers, not by practical technologists.

The education of technologists, and especially of engineers, has been discussed from many points of view, and anything I could say would be a personal opinion and therefore of little value unless I gave reasons which made it something more. I hold that the training at the university should be on thoroughly academic lines, because those are the lines on which the teachers are able to go far and well, and the whole of a student's available time is not too long to be devoted to a good groundwork of systematic coherent knowledge on which he can raise any desired superstructure of technology. The point I would insist on again is that he must not confuse the foundation with the superstructure. Though I am advocating the development of academic and not practical science at universities, I am not putting forward another argument, and that is the greater educational value of academic science. That is outside my subject, and I might be told I am not an expert on education. I do not know whether I am or not, as I do not know what an educationalist is, or what the symptoms are. Many think that professors and schoolmasters are experts in education. You might as well say that a shunting engine is an expert in locomotion. Those who take interest in the community want to get the locomotives off the old lines on to tracks suitable for the times, and such changes can be made by outside influence only against the bitterest conservatism. That education always sidetracks into useless absurdity is not due to any inherent wickedness of schoolmasters; it is the result of a kind of evolution, and is unavoidable.

Imagine, for instance, a school absolutely practical and sensible and perfectly in touch with real life. When a set of students grew old enough to leave, the most practical would go into outside life and a small selection would go into the teaching profession. This selection would not be deficient in ability, but it would be made up of the less practical, and more pedagogical men. In their generation as teachers the school would thus be a little more out of touch with life than before, and the next generation of masters would be the least practical of a batch of students themselves less practical as a whole; and the school would in due course get more and more senseless until it got down to the ordinary state. Educational institutions thus always contain the growing germs of their own ruin, and do so unavoidably. The teacher's position on a pedestal, his contact with the immature mind only, and his immunity from contradiction tend to foster the rapid growth of the germ. Outside influence ought to affect education, but has no power over it. Parents might control it by sending their sons where it is good and not where it is bad, but they do not care. A father will say: "Tom's education? Oh, yes. My father was at Rugbarrow and the 'Varsity, and so was I, so, of course, Tom goes, too. I had the ordinary education of a gentleman, and I am all right. There's nothing like the regular English public school and 'Varsity education." Closing the matter with this fact, he reconcentrates his attention on the study of "How to Train a Sporting Dog."

Universities do not train men to earn their living by practice in law, and more specially in medicine and surgery. How far our training is good I do not know. A medical man must go through either this course or one of the same kind before he is allowed to practice, so there is nothing to compare it with to see if it is good. If it is, universities have solved the problem of giving a technical as opposed to a purely academic course, but this needs the connection with hospitals. Nothing analogous is available in industry. If industrial concerns which are ill financially turned themselves over to the

treatment of university professors and students they might come to make big profits, but there is some doubt about it.

Imitations of engineering and chemical workshops have always the drawback that they are only imitations. The elements of time and price do not come in, and they are vital.

Technical schools, unlike universities, have the definite object of training students to make their living in industry, and they make their course as practical and as little academic as possible. A technical school is sometimes connected with a university, and we cannot in any case consider university training for industry without taking technical colleges into account. It must be admitted that if the best type of science training, even for industrial use, is the academic, the technical colleges are on wrong lines, and as technical colleges are doing splendid work, the idea put forward appears to be wrong. But it is not urged that the academic training is the best in every way, but that, on the whole, it is best because, first, the professors are able to effect it best; second, because a student has so little time to spare that it can best be laid out in acquiring a good, sound foundation; thirdly, a well trained mind with the academic can easily acquire the technical outlook, too; and, fourth, because academic science trains the mind to reason rather than to memorize, and deals with the facts of nature instead of the ideas or doings of other men just as foolish and illogical as ourselves. More than this, if the universities converted themselves into technical colleges, academic science and with it technology would get moribund. Whether technical colleges are on the best lines is another question. They may be badly designed for training the best class of technologist, while well suited for doing the best for men who have little time, and must be content with an inferior general foundation and a superstructure which is to a great extent imitation technology.

Recently we have heard a great deal about universities helping in scientific research. Research in academic science has little to do with national industry. All such research is published, and technologists all over the world utilize the results wherever the research is carried on. Research in academic science has no direct effect on national industry, but it has a great influence in rousing scientific enthusiasm, which is most important. But the outcry for scientific research for the benefit of industry is made chiefly by people who have no clear idea of the difference between academic and technical research, or of their circumstances. It is largely due to science teachers backed up by newspaper writers. The idea behind it is that manufacturers are ignorant and unscientific, and science teachers could put them right if allowed the chance. For example, we are told repeatedly that we are wasting coal, first, by burning it in badly designed furnaces; secondly, by refusing to extract the valuable hydrocarbons and ammonia; and that it will soon be used up at present rates and England will be ruined. As to the last point, coal that costs a consumer 10s. a ton is worth only a few pence in the ground to the owner. The rest of the cost is labor, carriage, interest on capital, profits, and so on. The present value of money at industrial interest a hundred years hence is about a hundredth, so that unless coal in the ground is going to be more than 100 times as valuable a century hence it pays better to sell now. If coal is worth 6d. a ton in the ground now, it pays the country better to use it at once than to wait for a century if it will then rise to 50s. But carriage from elsewhere will always keep it below any such fancy figure at £2 10s. a ton in the ground. Take the question of extracting the hydrocarbons and ammonia. It is ridiculous for science masters to tell technologists to extract valuable constituents. They are quite aware of the waste that goes on, and know that it will be reduced in the future. The technologists know infinitely more about coal distillation than the science masters, and they know what can be done commercially now and what cannot. If the science masters made some discoveries that could be utilized well and good, but to tell technologists that they are extravagant and ignorant is quite useless.

Can industrial research be carried on in teaching laboratories? During the war excellent work has been done, more especially in connection with such matters as dyes, drugs and glass. In these cases we were merely taking substances that had already been made and finding out how to make them. Finding out how to produce an existing dye is little in comparison with inventing the dye. The inventor did not know beforehand that there was any possibility of such a dye. After the war a number of undergraduates might be set to experiment on organic substances in the hope they might hit on something new and valuable. Such work would have no educational value, and its commercial result would be small. If one of them produced a new dye that got more brilliant the more it was sunned who would own the patent?

The vague idea seems to be that manufacturers have a number of definite problems they want solved, but they are too ignorant to solve them. They ought, therefore, to seek the advice of the universities, who would put them right. Manufacturers have no such problems. If you went to a cotton mill and asked the manager what problem he wanted to have solved, he might say, "You had better look round and see for yourself," or he might say something really quite different. If you went round you would find everything just so. No doubt every part is really capable of improvement, but no improvement suggests itself. Half or more of the merit of an invention is realizing that an improvement is wanted in any particular machine or process. One of the greatest difficulties the inventor has is to discover the "long felt want."

Take the question of recovery of hydrocarbons and ammonia from coal; students may carbonize coal in bits of gas barrel. This will not give much information as to the habits of a full-sized gas retort, but it may give some. Then they may distill tar, and fractionate the distillates and investigate them, but everything will be on a small scale except the mess. It is not the least likely undergraduates would find out anything in this way and teach it to manufacturers, and they would be merely wasting time and learning practically nothing. They might work under a professor, but it is a mistake to suppose a professor of organic chemistry knows the technical problems of tar distilling. Much of the chemistry is very special and otherwise uninteresting, but if the professor is going to master not only the special chemistry, but the commercial values of all the oils and the costs and practical merits of all the processes, he will have to give up his first-hand academic science to get time to fill himself up with second-hand technology.

But even if a research on tar distillation, for example, could be carried out satisfactorily in an educational laboratory, it could not be carried out in connection with an industrial distiller, because he would not work in with the laboratory unless he was to have a monopoly of the result. If the work is for publication, the tar distiller is not in the least interested, as it concerns his rivals here and abroad as well; so he will give neither information nor help. Results which are to be the common property of all, British or foreign, do not appeal to the individual manufacturer.

There is also a confusion between research and inven-

tion. It is not the least use turning a man or a group, and least of all a committee, on to invent. A committee of science professors would be as fit to make an invention as a council of professors of literature to fabricate a lyric. Industrial progress depends on invention, and we are the most inventive people in the world, not because we are the cleverest, but because we are the most individualistic and the least benumbed by education. Working out dye, scents and drugs is hardly invention; it is a rather lower type of chemical drudgery, which is above routine analysis, but much below original academic research. The better women chemists might tackle it. Inventions may be divided into two classes—improvements in machines or processes which can be made only by those in close touch with them inside the works, and broad inventions, which are generally made by complete outsiders whose minds are not in conventional grooves. In neither case can the university help.

Nothing is said about the shortcomings of the manufacturer, because I am not addressing him. He will not employ scientifically trained men, and he will not think very much of science generally until he finds that the technically trained men come to the front. Politicians, journalists, novelists, prelates and other superior people tell them they are going to the dogs. They make no reply, except such as can be gathered from the trade returns of the country. But the talking fraternity do not read trade returns. English manufacturers are, I maintain, the most competent of all. Eventually they may be better and they may employ science more, but to get them to do so sceince must adapt itself to industrial application.

I remember our chairman putting it that a man finds himself surrounded by a jungle of ignorance. He has not power or time to make roads in all directions, with cross roads, alleys and paths everywhere, so as to be acquainted with all the trees in the forest, and still less could he keep the ways all clear, as this means constant use of all of them. The best course is to make a few good roads in main directions, and to keep these in repair. He has then only a short path to make to get to any point. Thus, he ought to have a clear idea of the kinetic theory of gases, that is a very useful main road; the theory of the benzene ring; the principle of chemical action often going so that water is formed; the second law of thermodynamics; the conservation of energy; and the principles of mathematics, to mention a few main roads. Put in other words, this means that the technologist should have a thorough grounding in academic science, technology being added afterwards, and the university will have quite enough to do in supplying the groundwork as it ought to be.

Returning to the contention that education should have four chief aims: First, to enable one to earn his living; second, to enable him to live in good health; third, to make him a good citizen; and, fourth, to fit him to enjoy leisure when he has earned it. I would like to touch on a branch of the third.

Industry does not by any means depend alone on the types of science we have discussed. As a whole, it may be helped by the members of the community knowing something of economics, and acting on their knowledge; and it can be obstructed very effectively by the well-intentioned interference of those who know nothing of economics.

I have not been asked to give this lecture as an economist, so, even if I were an expert on the subject it would be unjustifiable for me to put forward conclusions based on political economy. It is, however, within my limits to say something, not as an expert, but as a student of economics, about the national importance of the subject.

Economics is a curious science. Though it is broadly about wealth, it does not help the individual to become wealthy. To an engineer the skillful application of the knowledge of the various physical sciences means success in manufacture which is good for him, and being good for him is good for the country. But a study of economics will not help him directly in his business at all; it is useful to him only as helping to make him a sensible citizen. He becomes a unit of sound opinion on labor problems, and on the action of Government in connection with industry. Unless, therefore, a man has the peculiar bent of mind which makes such a subject interesting in itself, he has no motive to lead him to read economics, until he recognizes it as a duty he owes to society.

Economics is peculiar in another way. If you ask any so-called educated man something about chemistry or mathematics, and he happens to know nothing of such subjects, he says so. People know when they are totally ignorant in such matters. But a man who is sublimely ignorant of economics is quite unconscious of his blind spot. He will lay down the law on such subjects as the relations of capital and labor, the birth rate, old age pensions, and, especially, international and colonial trade, with a cock-certainty, and a wealth of catch-words and circumambient balderdash that is almost good enough for a leading article in a daily paper. More than that, he will insist on acting according to his darks, and he is one of the units that determine the acts of the nation.

I will be told that political economy is taught widely at the universities. Something called economics may figure in the timetables and examinations; but it is either not taught at all, or it is not made a live subject. Perhaps, it is put in the wrong group of studies, and taught the wrong kind of student by the wrong kind of professor. I think Bagshot says something of the sort. That it is not taught efficiently is abundantly clear not only by the nonsense talked by what we called educated men on questions involving it, but more especially by the fact that people do not seem to realize that there is any such science. No sensible man would write an article involving a natural science of which he was profoundly ignorant, and if anyone who was not sensible did so, no competent editor would publish his product; but the high-class magazines, the best weekly papers, and, of course, the daily papers, are full of matter based on negative knowledge or nescience of economics. As to politicians, they do not limit their ignorance of science to economics; they make hay of all sciences and all facts with impartial irresponsibility.

It may be argued that I am putting economics on too high a pedestal; that economists are always gradually changing their views, and that they are sometimes narrow. Economists do not need me to bolster up their reputation. Every science is progressive. It is possible that if economics were treated properly even abler men might be attracted into it. At present there is little temptation to first-class men to specialize in political economy. The only goal is a university professorship, or the authorship of a treatise which will be read by other professors, or some of them, by a proofreader; and if I come across a reviewer's copy second-hand, I may cut it.

Not only the industry of the country, but the happiness of our people may depend on economics. At present we have practically the whole of the hand-working classes dissatisfied, and, therefore, unhappy. The social problem is the most important in the world at present. Its solution must depend on economics. Is it not worth while to study economics with such a purpose, instead of trying all sorts of schemes which are eco-

nomically pernicious? It may be true that economics has not so far provided any cut-and-dried way out; but until people realize that the science which ought to shed light on this path exists, and that it ought to be studied and developed, drawing the best intellects to it, there is no hope for any end, or even alleviation of the miseries of civilization.

I would urge that the first step is for the universities to teach economics, in which I include closely related branches of sociology, with the vigor and insight the subject deserves.

After the war, for instance, there will be many internal and international economical questions to settle. Who is going to settle them, and how?

First, public opinion is being educated. Public opinion is a collection of individual opinions. What we call our opinions are generally unfounded and ignorant prejudices that we wrangle about. When we get interested we hunt up all the arguments that we think will back our opinions up. No one with an opinion examines the matter to see whether his opinion is correct. If anyone has no opinion on hand, he gets one from a newspaper. It is manufactured for him ready made by journalists, novelists, publicists, politicians and everybody but those who know. Later, come committees of all sorts of people whose names are known, but not as economists, and they are supposed to command respect. There will be a sprinkling of business men, because there is a popular delusion that business has to do with economics, and that business men understand economical matters in a peculiarly practical way. In fact, the business man is the most dangerous of all, because he knows no more of the subject than other people; and he is not only unconscious of his ignorance, but he is, if possible, more certain he knows all about the matter. The opinion of such a body as a chamber of commerce on after-war trade conditions is most dangerous. It will be accepted as authoritative, it will be stated without any alleged reasons, and it will almost certainly be wrong.

Is it going too far to say that the war would never have come if the Germans had any true knowledge of economics? It is not for me to say. But surely I may say this: The war is either good or bad. If it is a bad thing, a competent general knowledge of economics would have rendered it absurd in the eyes of everybody, and, therefore, impossible.

Such a calamity as the war is not broadly somebody else's fault. It is the fault of all of us, but especially the fault of education, of which universities are at the head, in not educating us in such a way that such a catastrophe is out of the question.

Broadly, the great change wanted is in public opinion. Until people consider knowledge of the world we live in and the economical, sociological conditions of our life, as coming first, and the study of the sayings, doings and languages of other men, especially of those that lived when the knowledge of everything except human nature was in its babyhood, as quite secondary, we will no doubt go on with all the miseries of poverty, disease, discontent and war. Those who cannot get their ideas taken up by their contemporaries always think the simplest way is to get the next generation educated so as to adopt them readily. This is hopeless; education can be improved only by public opinion, and the reactionary tendency already mentioned is so strong that there is no hope of improving public opinion by education, because education has to be improved by public opinion, and it always lags a century or so behind, reacting on and really poisoning the only source of possible regeneration.

London, England.

The Thermal and Pressure Decomposition of Pentanes and Hexanes*

By Gustav Egloff

(Contribution from the Havemeyer Chemical Laboratory, Columbia University, No. 286)

With a view to ascertaining the mechanism of aromatic hydrocarbon formation from paraffins and the elimination of fractions from petroleum oils not conducive to their formation, a mixture of pentanes and hexanes was investigated. In a search of the literature upon the thermal decomposition of pentanes and hexanes, the products found were not aromatic in character, but mainly olefinic, dependent upon the temperature conditions. Previous workers had studied only the decomposition products of the gaseous and not of the liquid phase resulting from the reaction—if any liquid resulted under the conditions of their experiments. No attempt had apparently been made to study the liquid products resulting from the thermal decomposition of pentanes and hexanes. Hence, the present paper communicates the results in the formation of the aromatic hydrocarbons benzene, toluene, xylene, naphthalene and anthracene due to thermal and pressure decomposition of a mixture of pentanes and hexanes.

RESUMÉ OF THE LITERATURE

Norton and Andrews[1] passed the vapors of normal hexane, iso-hexane and pentane through a heated glass tube of 15 mm. diameter and 70 cm. in length. As to the thermal decomposition products of normal hexane the following hydrocarbons were identified; ethylene, propylene, butine, amylene, hexylene, benzene and gases unabsorbed by bromine. At a "bright red heat" the products resulting from the decomposition of iso-hexane were found to be ethylene, propylene, butylene, amylene, hexylene, butine, no benzene and gases not absorbed by bromine. Under similar conditions pentane gave the hydrocarbons ethylene, propylene, butine, no benzene and unabsorbable hydrocarbons in bromine. They report finding benzene as a decomposition product of normal hexane and none from the iso-compound or from pentane. They do not report toluene, xylene, naphthalene or anthracene as decomposition products of the three hydrocarbons experimented with. This can only be ascribed to the factors of temperature, contact surface and time, or length of time the vapors were in the reacting zone; the conditions for aromatic formation which were not fulfilled in their experiments.

Haber[2] in a study of the thermal decomposition of normal hexane came to the conclusion that its primary decomposition was similar to the higher paraffin hydrocarbons in splitting off the terminal group. The normal hexane was passed in the gas condition through a tube ⅛ in. in diameter and 25 in. in length, at temperatures between 448 deg. C. and 800 deg. C. The hexane showed between the temperatures of 448 deg. and 518 deg. C. no signs of decomposition. At temperatures between 600 deg. and 700 deg. C., however, the gas contained somewhat over 50 per cent of olefins, 34 to 37 per cent of saturated hydrocarbons (of which 70 per cent was methane), and 10 to 13 per cent of hydrogen. He isolated some benzene but does not report any other aromatic hydrocarbons being formed. This is to be expected when one considers the length and diameter of the heated tube utilized in his experiments.

Although the temperatures used in his experiments are high in comparison to those used in the present paper, yet one would expect similar results if the time fac-

*A paper delivered before the organic section of the 53d meeting of the American Chemical Society, September, 1916.

[1] *Amer. Chem. Jour.* 8, 1, 1886.

[2] *Jour. Gasbel.* 39 (1896), 377, 395, 435, 452, 799, 813 and 830.

tor for aromatic formation had been maintained at the temperatures Haber used. His work is significant, however, in that he endeavored to show the primary decomposition of normal hexane, which would throw light upon the mechanism of the higher aliphatic hydrocarbon reactions. From a number of experiments he concluded that the primary reaction of the thermal decomposition of normal hexane gave amylene and methane according to the equation:

$$H_3C - CH_2 - CH_2 - CH_2 - CH_2 - CH_3 \rightarrow C_5H_{10} + CH_4.$$

From the relative amounts of the gaseous and liquid olefins, and the mean molecular weight of the gaseous olefins he concluded that as a secondary reaction a portion of the amylene decomposed to form propylene and ethylene as follows:

$$H_3C - CH_2 - CH_2 - CH = CH_2 \rightarrow H_2C = CH_2 + H_2C - CH = CH_2$$

From combustion data of the gases formed from the decomposition of the hexane at a temperature of 600 deg. C. and higher he believed that *naphthenes* were likewise formed. Also that by the splitting off of methane from amylene, crotonylene was formed according to the equation:

$$H_3C - CH_2 - CH_2 - CH = CH_2 \rightarrow H_2C - C \equiv C - CH_3 + CH_4$$

Haber concluded that the primary decomposition of the higher aliphatic hydrocarbons was by the splitting off of the terminal methyl groups of less than three carbon atoms.

Ipatiew and Dowgelewitch[3] passed the vapors of hexane through a "tube" at 710 deg. C. The decomposition products analyzed, in the gas, 50 per cent of olefins, 41.6 per cent paraffins, and 8.4 per cent of hydrogen. The individual hydrocarbons were identified as the bromides, ethylene, propylene and probably isobutylene. No aromatic hydrocarbons were isolated or identified.

ANALYSIS OF PENTANES AND HEXANES USED

The mixture of pentanes and hexanes used in the following experiments were derived from "petroleum ether." The petroleum ether was thoroughly washed with c.p. sulphuric acid of specific gravity 1.84 for the removal of any unsaturated hydrocarbons present. The acid present was then neutralized with a sodium hydroxide solution, washed with distilled water and dried over fused calcium chloride. The mixture was distilled by means of a Hempel column and the specific gravity taken by using a Westphal balance at 15.5 deg. C. The analytical results are expressed in Table 1.

TABLE I—SPECIFIC GRAVITY 0.656/15.5 DEGREES C

Temperature, Degree C	Per Cent by Volume	Specific Gravity, 15.5 Degrees C.
27	First drop	.....
27 to 40	36.0	0.630
40 to 60	29.0	0.655
60 to 70	34.2	0.660
70 to 74	Dry point	.....

EXPERIMENTAL METHOD

The mixture of pentanes and hexanes was passed through a heated lap-welded steel tube of 1½ in. diameter and 72 in. in length at temperatures of 450 deg., 500 deg., 650 deg. and 725 deg. C. Sixty inches of the steel tube were heated by means of 12 gage nichrome resistance wire, three turns to the inch insulated by means of mica or asbestos sheets from contact with the steel tube. At the middle of the tube a ¾-in. pipe of 6-in. length was welded and a base metal thermocouple inserted through a stuffing box. The electric furnace was set in an 8-in. square steel case packed with asbestos packing for insulation. The liquid was passed into the heated area at a definite rate of 300 cc. per hour by means of a lubricating cup device of 900 c.c. capacity. Six hundred cubic centimeters of pentanes and hexanes was used in each experiment. The rate of oil flow was carefully maintained since even slight variations in this factor would give appreciable differences of percentage yields of the various products resulting from the thermal and pressure decomposition of the starting material. The base metal thermocouple was calibrated against a platinum-iridium thermocouple and was found to be accurate within plus or minus 5 deg. C.

The pressure of the system when using twelve atmospheres was built up by means of an air compressor using natural gas for these experiments. When twelve atmospheres pressure were shown on the gage the compressor was shut down and the oil flow started. As the decomposition of the pentanes and hexanes took place the products of the reaction passed on down through an adequate condensing system consisting of a steel worm packed in an ice-water freezing mixture. The pressure of twelve atmospheres was maintained by means of a globe valve and was not allowed to vary during the experiment.

The analysis of the recovered oils for aromatic content has been given elsewhere.[4]

DISCUSSION OF EXPERIMENTAL DATA

A. TABLE II—THE PER CENT OF RECOVERED OILS, AND THE SPECIFIC GRAVITY OF THE RECOVERED OILS AT VARYING TEMPERATURES AND PRESSURES

Temperature of run, degree C.....	450		500		650		725
Pressure in atmospheres.	1	12		12	1	12	1
Per cent of recovered oil	72.0	49.0	45.1	14.0	6.7	0.0	0.0
Specific gravity.....	0.772	0.778	0.780	0.790	0.901	...	...

As is usual in thermal and pressure decomposition work, the percentage yield on the basis of starting oil decreases with increase of temperature and pressure. In going from 450 deg. C. to 725 deg. C. at one atmosphere pressure the percentage yield decreased from 72 per cent to 0.0 per cent. By increasing the pressure to 12 atmospheres, the yield of recovered oil decreased from 49 per cent at 450 deg. C. to 0.0 per cent at 650 deg. C. An increase to 12 atmospheres pressure decreased the temperature of total decomposition of the starting oil, to carbon and gas, 75 deg. C. Greater decomposition of the pentanes and hexanes took place at the elevated pressure when the temperature was held constant. At 550 deg. C. 12 atmospheres gave 86 per cent of the initial oil as carbon and gas, while one atmosphere pressure gave a 55.9 per cent value at the same temperature.

The specific gravity of the recovered oil increased with rise of temperature and pressure, as expected, due to the formation of aromatic hydrocarbons of the benzene, naphthalene and anthracene series from the much lower specific gravitied paraffin hydrocarbons, pentanes and hexanes.

At the lowest temperature used, in these experiments, 450 deg. C. and atmospheric pressure, the highest percentage of aromatic compound formation was xylene 8.2, which would indicate that the methyl derivatives of benzene formed more readily than benzene;

[3] Berichte 44, 2987, 1911

[4] Egloff and Twomey, *Jour. Phys. Chem.* 20, 121, 1916.

B. Table III—The per Cent of the Aromatic Hydro-Carbons in the Recovered Oils

Temperature, degree C.	450		500		650		725
Pressure in atmospheres.	1	12	1	12	1	12	1
Per cent benzene	2.0	6.5	2.9	13.8	15.1	0.0	0.0
Per cent toluene	6.9	4.2	6.4	5.0	5.9	0.0	0.0
Per cent xylene	8.2	5.8	6.1	2.4	5.0	0.0	0.0
Per cent naphthalene	2.1	2.8	3.8	4.8	5.6	0.0	0.0
Per cent anthracene	0.8	1.9	2.8	4.0	4.2	0.0	0.0

for at the same temperature toluene formed to the extent of 6.9 per cent, while benzene gave only 2 per cent. But when the pressure was raised to 12 atmospheres the percentage yield of benzene increased above that of either xylene or toluene. The increase for benzene was 4.5 per cent over the atmospheric pressure condition and the decreased percentage yield of the xylene and toluene together was 5.1 per cent, while the naphthalene increased 0.7 per cent and the anthracene 1.1 per cent under increased pressure conditions, which would lead one to believe that the xylene and toluene formed under atmospheric pressure, in the main, decomposed to form the benzene, naphthalene and anthracene at the elevated pressure. This is strictly in accord with Le Chatelier's principle of those products forming most readily which diminish in volume under pressure. Of course, it can readily be understood that no one of these reactions takes place by and of itself, for side reactions are taking place which profoundly influence the products resulting.

The data at 500 deg. C. give somewhat similar results, although the benzene increased over 450 per cent when the pressure was raised to 12 atmospheres, which percentage is not indicated to be all derived from the percentage decomposition of the xylene and toluene.

At 650 deg. C. the maximum formation of benzene is shown at atmospheric pressure, while a change to 12 atmospheres gives the total decomposition of the starting oil to carbon and gas. The total decomposition of the starting material to carbon and gas takes place also at atmospheric pressure and 725 deg. C.

Increase of temperature and pressure was favorable to the formation of naphthalene and anthracene, which is in accord with earlier findings from the thermal decomposition of high boiling point aliphatic hydrocarbons.[5]

C. Table IV—Analysis of the per Cent of the Aromatic Hydrocarbons on the Basis of Pentanes and Hexanes Used

Temperature, degree C.	450		500		650		725
Pressure in atmospheres.	1	12	1	12	1	12	1
Per cent benzene	1.4	3.2	1.3	1.9	1.0	0.0	0.0
Per cent toluene	5.0	2.1	2.9	0.7	0.4	0.0	0.0
Per cent xylene	5.9	2.7	2.8	0.3	0.3	0.0	0.0
Per cent naphthalene	1.5	1.4	1.7	0.7	0.4	0.0	0.0
Per cent anthracene	0.6	0.9	1.2	0.6	0.3	0.0	0.0

When calculating the percentage of benzene, toluene, xylene, naphthalene and anthracene upon the basis of pentanes and hexanes used, the percentage relationship changes widely from the value for these substances in the recovered oil. The per cent of benzene, toluene and xylene decreases with increase of temperature. The naphthalene and anthracene reached a maximum with increase of temperature but decreased with increase of pressure. The formation of benzene increased with increase of pressure while toluene and xylene fell off in percentage yield.

The maximum formation of benzene occurred at 450 deg. C. with 12 atmospheres, and for toluene and xylene at the same temperature, but at one atmosphere pressure.

[5]Egloff and Twomey, *Jour. Phys. Chem.* 20, 121, 1916.

Mechanism of the Reaction

In the thermal and pressure decomposition of the mixture of pentanes and hexanes under the conditions of the present experiments the main products of aromatic type in the liquid phase were benzene, toluene, xylene, naphthalene and anthracene. From the experimental data and conclusions of previous workers as to the products formed in the gas phase from the thermal decomposition of pentanes and hexanes there will be built up a mechanism of aromatic formation mainly deduced from the hydrocarbons isolated from the reaction.

Haber[6] indicated quite clearly that the primary decomposition of normal hexane resulted in the formation of amylene and methane according to the equation:

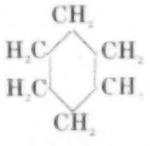
$$H_3C - CH_2 - CH_2 - CH_2 - CH_2 - CH_3 \rightarrow CH_2 - CH_2 - CH_2 - CH = CH_2 + CH_4$$

and that a secondary reaction then takes place which results in the formation of ethylene and propylene from amylene, as shown by the following equation:

$$H_3C - CH_2 - CH_2 - CH = CH_2 \rightarrow H_2C = CH_2 + H_3C - CH = CH_2$$

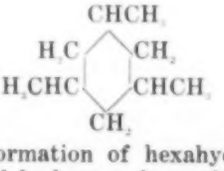
From combustion data he concluded that naphthenes were also formed in decomposing normal hexane. From this it can readily be seen that 3 moles of ethylene can form 1 mole of hexahydrobenzene according to:

$$3H_2C = CH_2 \rightarrow$$

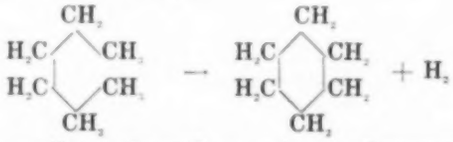


and that 3 moles of propylene can readily form 1 mole of hexahydromesitylene as the following equation indicates:

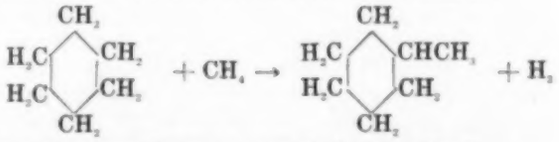
$$3H_3C - CH = CH_2 \rightarrow$$



A purely hypothetical formation of hexahydrobenzene from the splitting off of hydrogen from the terminal carbon atoms of the normal hexane can be shown quite similarly to the formation of naphthenes by means of the Freund reaction or the Perkins method by use of the brom derivatives and sodium. The following equation illustrates the reaction:



From the methane formed as primary decomposition product, according to the first equation, reacting with the hexahydrobenzene from either of the two above ways, hexahydrotoluene could form according to:



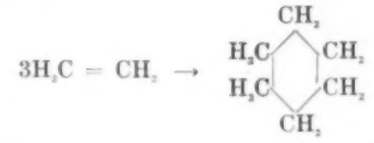
The two last equations are purely hypothetical.

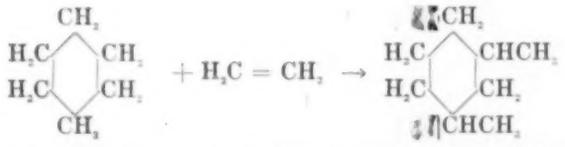
De Montmollin[7] has analyzed the complex mixture of

[6]*Jour. Gasbel*, 39 (1896), 377, 395, 435, 452, 799, 813 and 830.
[7]Bull. Soc. Chim. 19, 242, (1916).

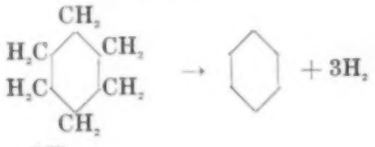
hydrocarbons formed by the action of phosphoric acid and alcohol in producing ethylene. This hydrocarbon liquid was composed mainly of the polymethylenes-cyclohexane homologs, together with saturated and unsaturated aliphatic hydrocarbons with some aromatic substances also present. The following substances were isolated in a pure condition: di-isopropyl, dimethyl-diethyl methane, hexahydro-m-xylene and hexahydro-p-xylene as also hexahydrocymene and hexahydrocumene.

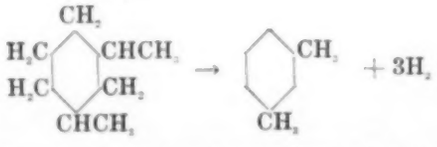
From this evidence of the polymerization of ethylene to alicyclic compounds the formation of aromatic hydrocarbons from such polymethylenes by decomposition from thermal and pressure conditions can be readily followed. It is well known that ethylene is one of the decomposition products of all paraffin hydrocarbons subjected to temperature and pressure conditions, and with the exception of methane persists longest as a product of the reaction. The synthesis of hexahydrobenzene can be readily followed by means of ethylene first forming hexahydrobenzene and then reacting with 1 mole of ethylene forming hexahydroxylene as shown by the following equations:



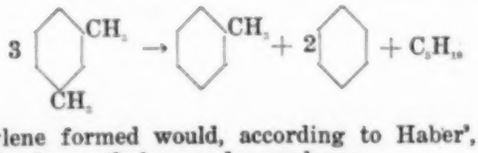


Now these naphthenes or better termed alicyclic hydrocarbons are not stable at elevated temperatures, decomposing readily to the aromatic hydrocarbons benzene and xylene (o) (m) (p), and splitting off hydrogen in the reaction. The equations following illustrate the direction of the reaction at the temperatures and pressures used in these experiments:





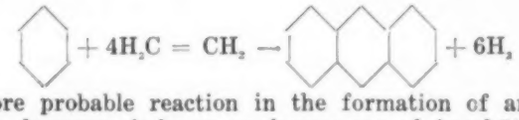
In previous work[9] it has been shown that the three isomers of xylene decomposed, with a tendency to form toluene, benzene, naphthalene and anthracene. Now 3 moles of xylene can readily give 1 mole of toluene, 2 moles of benzene and 1 mole of amylene, as follows:



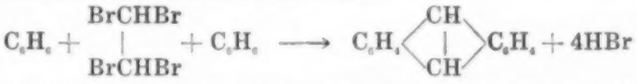
The amylene formed would, according to Haber[9], decompose to form ethylene and propylene:

$$C_5H_{10} \longrightarrow C_2H_4 + C_3H_6$$

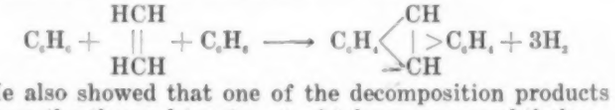
The work of Ferko[10], who passed ethylene and benzene through a "hot" tube isolated as one of the decomposition products anthracene, but no naphthalene. The mechanism of anthracene formation may possibly be as follows:



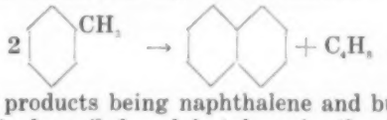
The more probable reaction in the formation of anthracene, however, is by an analogous one of Anschütz, who treated tetrabromethane and benzene with aluminium chloride, forming anthracene:



Instead of tetrabromethane being used, ethylene could quite readily form anthracene as follows:



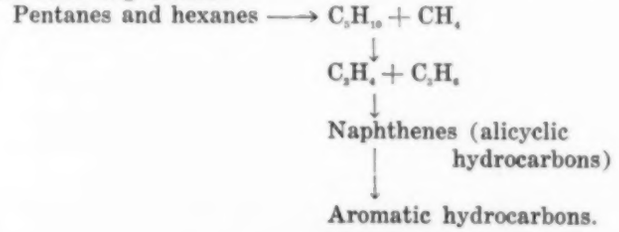
He also showed that one of the decomposition products from the thermal treatment of toluene was naphthalene, as also did Rittman, Byron and Egloff.[11] The course of the reaction would probably be as follows:



The resulting products being naphthalene and butylene. Norton and Andrews[12] found butylene in the thermal decomposition of normal hexane, but do not report any formation of naphthalene.

Due to the dominancy of Berthelot's theoretical conclusions as to the mechanism of aromatic formation from low boiling hydrocarbons, upon scant experimental evidence other workers in the field have taken his lead in indicating the apparent necessity of passing through the acetylene stage of polymerization to benzene and then to higher homologs. From the experimental evidences of the various workers this cannot be true, for in most cases no acetylenes were found, although special precautions were taken to isolate same, and wherever found were present only in slight amounts. That acetylene polymerizes to form benzene is certain, but as to whether the main source of aromatic hydrocarbons resulting from the thermal decomposition of paraffin hydrocarbons via acetylene formation is more than questionable. From the experiments of decomposition of the mixture of pentanes and hexanes at the low temperatures used in this series, it is doubtful that acetylene or its homologs are formed.

From the experimental evidence gathered the mechanism of the reaction in the formation of aromatic hydrocarbons from the aliphatic hydrocarbons used indicate the following course:



GENERAL DISCUSSION

A mixture of pentanes and hexanes is conducive to aromatic formation at low temperatures. At elevated temperatures the decomposition of the mixture goes totally to gas and carbon. From the experimental evidence of previous workers and the present set of experiments a mechanism of aromatic hydrocarbon formation has been built up.

[9] Rittman, Byron and Egloff, *Jour. Ind. Eng. Chem.*, 7, 1019, 1915.
[10] Loc. cit.
[10] Berichte 20, 660, 1887.
[11] *Jour. Ind. Eng. Chem.* 7, 1019, 1915.
[12] Ibid.

It is quite certain that all paraffin hydrocarbons lend themselves to aromatic formation, even the highly stable methane. The work of Zanetti[13] is significant in that he produced aromatic hydrocarbons from the thermal decomposition of mixtures of ethane-propane; propane and butane derived from the condensate of natural gas. This leaves methane as the main paraffin hydrocarbon which, as far as the author is aware, has not been converted into aromatic hydrocarbons. There is no doubt that under proper temperature, pressure, concentration, time and surface contact conditions, methane can also be converted into aromatic hydrocarbons of the benzene, naphthalene and anthracene series.

SUMMARY

1. A mixture of pentanes and hexanes has been subjected to temperatures of 450, 500, 650 and 725 deg. C. and pressures of 1 and 12 atmospheres for the formation of benzene, toluene, xylene, naphthalene and anthracene.

2. The percentage yield of recovered oil decreased with increase of temperature and pressure. The maximum yield occurred at 450 deg. C. and 1 atmosphere pressure. At 650 deg. C. and 12 atmospheres the starting oil decomposed completely to carbon and gas. The same result was recorded at 1 atmosphere and 725 deg. C.

3. The percentage of benzene in the recovered oil increased with increase of temperature and pressure; the maximum of 15.1 per cent was found to occur at 650 deg. C. and 1 atmosphere pressure. The percentage yield for toluene and xylene decreased with increase of temperature and pressure. The maximum per cent for toluene was 6.9 and 8.2 for xylene, both at 450 deg. C. and 1 atmosphere. The percent of naphthalene and anthracene increased with temperature and pressure, giving as a maximum for naphthalene 5.6 per cent and for anthracene 4.2 at 650 deg. C. and 1 atmosphere.

4. The per cent of benzene, toluene and xylene decreased with temperature and pressure increase on the basis of pentanes and hexanes used. A maximum of 3.2 for benzene was noted at 450 deg. C. and 12 atmospheres, while toluene gave 5.0 per cent and xylene 5.9 at the same temperature and 1 atmosphere. The formation of naphthalene and anthracene increased with temperature and decreased with pressure. The maximum for naphthalene gave 1.7 per cent and 1.2 for anthracene, both occurring at 500 deg. C. and 1 atmosphere.

5. A mixture of pentanes and hexanes is conducive to the formation of aromatic hydrocarbons at low temperatures.

6. The mechanism of aromatic formation from pentanes and hexanes is in all likelihood as follows:

Pentanes and hexanes $\longrightarrow C_5H_{10} + CH_4$

$\downarrow$

$C_2H_4 + C_3H_6$

$\downarrow$

Naphthenes (alicyclic hydrocarbons)

$\downarrow$

Aromatic hydrocarbons.

Columbia University, N. Y. City.
Department of Chemistry,

[13]Zanetti, *Jour. Ind. Eng. Chem.* 8, 674, 1916. Zanetti and Leslie, Ibid. 8, 777, 1916.

Mining Course for Practical Men.—The twentieth annual short session of the College of Mines of the University of Washington, Seattle, Wash., will open Jan. 2 and end April 1. Courses offered include prospecting, mining, milling, assaying and smelting, and are for the benefit of those unable to enroll for the regular college work.

The Utilization of Waste Heat for Steam-Generating Purposes*

By Arthur D. Pratt

The utilization of waste heat from various industrial processes for the generation of steam is not new. The advance within the last few years, however, in methods of utilizing such gases and in the results secured from their utilization has been so remarkable as to make of interest a comparison of former with present-day methods and results.

The design of waste-heat boilers has progressed to a point where it is to-day possible to generate steam successfully from gases whose temperatures are as low as 950 or 1000 deg. Fahr. It is but a few years since it was considered absolutely impracticable from a commercial standpoint to attempt to produce power from such gases, and it is in its ability to satisfactorily utilize these gases that the development of the modern waste-heat boiler has its most far-reaching effect.

The sole theory on which early waste-heat boiler installations were made had as its basis the non-interference in the operation of the primary furnace. This meant, in practically all cases, that the draft at the exit of the primary furnace should in no way be impeded, and resulted in the installation of a given amount of heating surface arranged in such manner that the frictional resistance to the gases in their passage through the boiler should be a minimum. Presumably the object of such an arrangement was to enable a natural-draft stack of a practicable height to be used. As the result of minimizing this draft loss, such boilers as were installed were ordinarily entirely without baffles and the gases were given a straight passage through the boiler, though partially baffled boilers were used occasionally. High exit gas temperatures were considered rather desirable than otherwise in order to assist the stack in giving the required drafts.

Boilers installed in this way were considered practicable only with gases whose temperatures approached those of coal-fired practice. The users accepted the steam generated as "something for nothing," and no particular endeavor was apparently made toward increased capacities.

Present-day waste-heat practice has come about with a more thorough understanding of the laws governing heat transfer and an appreciation of the function of gas velocity as affecting transfer rates. Without going into this aspect, it may be broadly stated that the rate of heat transfer is dependent upon gas velocity and temperature difference between the gas and the absorbing surface. Experiments have shown that at even the highest velocities now used in waste-heat work the effect of increased temperature difference is small as compared with that of increased gas velocity.

In coal-fired-boiler practice the average temperature difference between gases and boiler surfaces is approximately 1150 deg. The heat-transfer rate corresponding to a boiler's rated capacity is about 3 B.t.u. per hour per square foot of surface per degree difference, or a heat absorption of 3450 B.t.u. per square foot of surface per hour. In waste-heat work the temperature difference varies widely with the class of waste heat. With a gas temperature, say, of 1250 deg. entering a boiler, the average temperature difference between boiler surfac and gas for a working pressure of 170 lb. per square inch will be about 500 deg. For such a temperature difference the transfer rate, to give an absorption per square foot of surface equal to that of the coal-fired boiler at rating, would have to be 6.9 B.t.u. per hour

*A paper presented at the annual meeting of the American Society of Mechanical Engineers on Dec. 6, 1916, in New York. All temperatures in this paper are given in degrees Fahr.

per square foot per degree difference. This rate is slightly higher than the rates corresponding to velocities that are as yet ordinarily used, but with somewhat higher entering gas temperatures the absorption per square foot of surface is such as to enable a boiler's rated capacity to be developed without difficulty. With gas temperatures entering the boiler of 1800 to 2000 deg., which approach coal-fired practice, high overloads are being developed.

The gas velocities necessary to give what is now considered a desirable transfer rate lead to a frictional resistance through waste-heat boilers which makes the use of a natural-draft stack impracticable. Let us consider what is probably the extreme case in so far as draft conditions are concerned, namely, the open-hearth steel furnace. Common practice in this class of work is to use stacks 160 ft. high, which give a draft at their base approximately 1.4 to 1.6 in., depending upon the gas temperatures. For the present purpose, assume that the draft loss through a modern waste-heat boiler installed with an open-hearth furnace is 2.0 in., a figure which approximately represents the practice of to-day. With a natural-draft stack, the draft at the checkers corresponding to the 1.4 to 1.6 in. given above is approximately 1.3 to 1.5 in., and this amount is necessary for the proper operation of the furnace. With a waste-heat boiler installed, then, the draft necessary at the exit of the boiler must be sufficient to overcome the resistance through the boiler, 2 in., that necessary to overcome resistance through the flues, say 0.75 in., and 1.5 in. necessary at the checkers, or a total of 4.25 in. It is to be remembered that with a waste-heat boiler installed, the temperature of the gases entering the stack, instead of being 1000 or 1200 deg., will be 450 or 500 deg., under which conditions a stack of 160 ft. instead of giving a draft of 1.4 to 1.6 in. at its base would give approximately 0.9 in., and to give the necessary 4.25 in. the stack height would have to be somewhat over 700 ft.

While, as stated, this is perhaps the extreme case, the same reasoning applies in practically all waste-heat work, and an induced-draft unit is now almost universally used with the modern design of waste-heat boiler. In certain classes of waste-heat work, such a fan not only furnishes the required draft suction, but is of a decided advantage in the operation of the primary furnace. This feature will be discussed in connection with the individual classes of waste heat later considered.

As may be inferred from the foregoing, the successful utilization of waste gases becomes more difficult with decreasing gas temperatures. It was in connection with regenerative furnaces and low-temperature gases that the principles of high gas velocity were first applied and the modern waste-heat boiler was developed. The success of the early installations in this particular class of work led to the application of this theory to all classes of waste-heat practice.

Waste-heat boilers of the modern design are in successful operation to-day with copper-refining furnaces, cement kilns, open-hearth steel furnaces, beehive coke ovens, zinc-refining furnaces and heating furnaces of various types, both regenerative and non-regenerative.

As stated, the waste-heat boiler of to-day was developed with low-temperature gases and its largest field, until the present, has been with open-hearth steel furnaces. For this reason this class of waste-heat work will be considered first.

Open-Hearth Steel Furnaces

This particular phase of waste-heat work may be considered new. In the open-hearth steel furnace we have the best and by far the most numerous examples

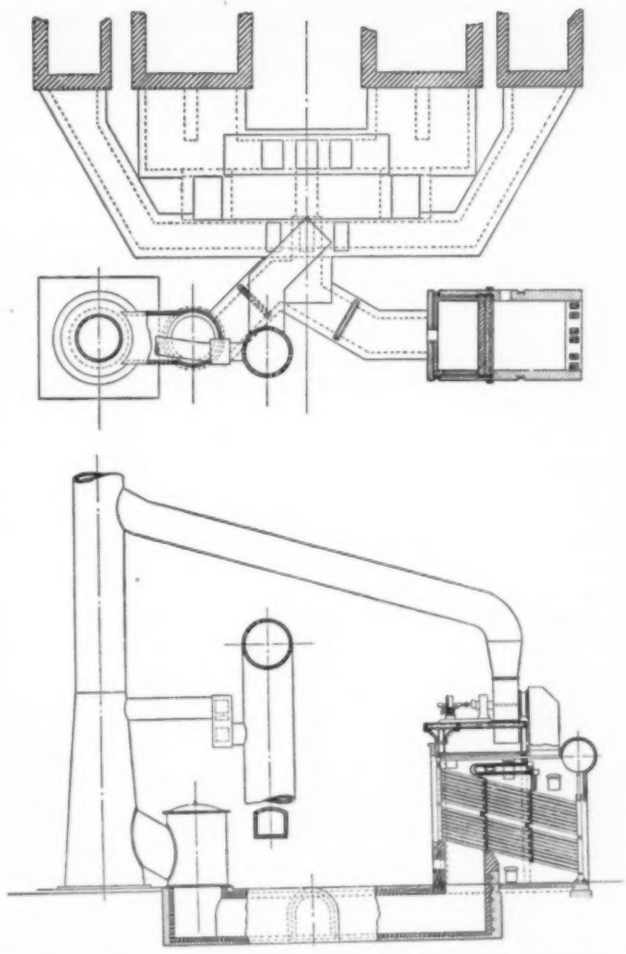


FIG. 1—WASTE-HEAT BOILER FOR OPEN-HEARTH FURNACE

of the regenerative furnace. From the very nature of the operation of such furnaces, gas temperatures passing to the stack are low, and the ability of the modern waste-heat boiler to utilize successfully these gases for the generation of steam is, without question, the best proof of the progress in the development of this particular class of boiler.

An experimental waste-heat boiler for this work, embodying the principles but possibly not the design of the modern waste-heat boiler, was installed at the South Chicago plant of the Illinois Steel Company, in 1910. The results from this installation, while by no means comparable with those secured to-day with the more highly developed design, so clearly indicated possible savings in the practically untried field of open-hearth practice that two boilers, the design of which may be considered well past the experimental stage, were purchased for this same plant in 1911.

C. J. Bacon, Mem. Am. Soc. M.E., steam engineer of the Illinois Steel Company, presented before the American Iron and Steel Institute in May, 1915, a paper, Waste Heat Boilers for Open Hearth Furnaces, in which he describes the experimental boiler referred to, and traces the development in this class of work through the first three installations made.

The first of these, at the plant of the Illinois Steel Company, in South Chicago, consisted of two Stirling boilers equipped with special cross baffles to give the desired gas velocities over the heating surfaces.

The second installation, made at the Gary plant of the Indiana Steel Company, consisted of twenty-eight special 6-drum Rust boilers equipped as in the case of the Stirling boilers with special cross baffles.

The third installation described is that made at the

Pencoyd Works of the American Bridge Co. and consists of a cross-drum Babcock and Wilcox boiler, the width of boiler and the tube length being such as to give the gas-passage areas necessary for the required gas velocity. For low-temperature waste-heat work, the type of boiler of which this installation is an example is in general best suited. Fig. 1 shows a typical layout of a boiler of this last design.

Table 1 gives the results secured from the Stirling and Rust boilers described and from Babcock and Wilcox boilers similar in design to that installed at Pencoyd, though set with considerably larger open-hearth furnaces. That the three installations described by Bacon are truly progressive, at least from the aspect of heat absorption, may be seen from the results given in this table.

Tests 1, 2 and 3 are as given in Bacon's paper and its discussion. Test 4 is included as being of interest in indicating the results that may be secured with gases at a temperature considerably below that ordinarily found in open-hearth work. At this particular plant the gas temperatures leaving the checkers were not appreciably lower than in other tilting furnaces, but the necessary flue arrangement was such that there was an excessive radiation loss between the checkers and the boiler from flues and reversing valves.

In Table 1, as in the following tables, the proper basis for the comparison of results is the rate of heat transfer, but in order that such a comparison may be intelligent, it is necessary in connection with the transfer rates to give proper consideration to the gas weights per square foot of heating surface, entering and exit gas temperatures, and the percentage of rated capacity developed. To give a direct comparison of the performance of two different boilers, the gas weight per square foot of heating surface and the entering gas temperature should be the same.

It is possible from our present knowledge of the laws of heat transfer to compute with surprising accuracy the results that may be expected from any boiler for a given set of conditions. Let us consider, then, the results which the boiler of Test No. 4 would give under the gas conditions of Test No. 1. For a weight of gas per square foot of surface corresponding to Test No. 1, the total weight of Test No. 4 would become 98,950 lb. per hour.

With this weight passing through the boiler of Test No. 4, at the temperature actually existing in No. 4, the boiler would develop approximately 363 hp., or 67 per cent of its rated capacity. With an entering temperature equal to that in Test No. 1, the boiler would develop approximately 500 hp., or 92 per cent of its rated capacity. These figures are included simply to show the importance of giving all factors proper consideration where a comparison of results is to be made.

TABLE I—RESULTS OF TESTS OF WASTE-HEAT BOILERS FOR OPEN-HEARTH FURNACES

Test Number	1[1]	2	3	4
Plant	Illinois Steel Co.	Indiana Steel Co.	Bethlehem Steel Co.	Lackawanna Steel Co.
Location	So. Chicago, Ill.	Gary, Ind.	So. Bethlehem, Pa.	Buffalo, N. Y.
Rated capacity of furnace, tons	65	75	80	[5]
Actual production, tons	72[2]	85	82.6	.....
Boiler	Stirling	Rust	B. & W.	B. & W.
Heating surface, sq. ft.	4,000	4,880	5,232	5,407
Superheat, deg. Fahr.	128	176	121	97
Gas weight, lb. per hr.	73,000	83,434	75,271	78,947
Gas per hr. per sq. ft. of h.s., lb.	18.3	17.1	14.4	14.6
Temperatures:				
Gas entering boiler, deg. Fahr.	1,227	1,155	1,362	986
Gas leaving boiler, deg. Fahr.	621	530	493	468
Drop in temp., deg. Fahr.	606	625	869	518
Draft at boiler inlet, in.	.....	1.47	1.55	1.76
Draft at boiler damper, in.	.....	3.95	3.29	3.63
Draft loss, in.	1.78	2.48	1.74	1.87
Gross h.p. developed	334.5	393	425.8	306
Per cent of rated capacity[6]	83.6	80.6	81.4	56.7
Boiler h p. to fan	[3]	60[4]	24.3[3]	.....
Net horsepower	.....	386	401.5	.....
Approximate transfer rate (K)	5.08	6.92	4.77	5.12

[1]Average of ten tests.
[2]Approximate.
[3]Motor-driven fan.
[4]53 h.p. returned in feed-water heater.
[5]Tilting furnace.
[6]All ratings are on the basis of 10 sq. ft. per h.p.

In connection with waste-heat boilers there are certain features of installation and operation, some of which refer specifically to open-hearth work and others to waste-heat work in general, that are of interest. While these features are discussed here, they will apply in certain of the other classes of waste-heat work considered later.

LOCATION OF BOILERS

The early boiler installations were made with open-hearth furnaces already in operation. With these furnaces it was necessary to connect the boiler to the flue between the reversing valves and the stack, the boiler thus being on a branch flue while the stack was on the more direct connection. It was and is common practice, in laying out open-hearth furnaces, to place the stack central with the furnace, and wherever such an arrangement is followed the boiler would of necessity be on the branch flue.

It is recommended, and to-day this recommendation is being more or less followed. that the boiler be placed central with the furnace and the by-pass stack on the branch connection. Such an arrangement will give a straight gas passage to the boiler, minimizing frictional resistance in the connecting flues due to the absence of turns, and will have a tendency to give an equal distribution of the gases across the width of the boiler.

A further advantage of such an arrangement is that better protection is given to the by-pass stack damper. These dampers are ordinarily of cast iron, and where they close a direct passage to the stack, they are subjected to temperatures considerably higher than if the stack were on the branch connection and this damper installed on such connection.

CONNECTING FLUES

The flues from the reversing valves to the boiler should be as short as possible to minimize radiation losses. The location of such flues, with the same object in view, is also of importance. Ordinarily these are placed underground, and their depth beneath the surface should be such as to furnish a sufficiently thick insulating layer of earth on top. The best practice is to make this layer from 3 to 4 ft. thick. In one installation where, because of certain unavoidable conditions, the thickness of the earth covering on the top of the flue was something less than 1 ft., the temperature of the surface of this earth was over 400 deg. The loss from radiation from such a flue is obvious.

Ample means should be supplied for keeping these connecting flues clean, and the area should be such as to allow a certain amount of accumulation of dust when the furnace is down without impeding the draft. The average life of an open-hearth furnace is probably around 300 heats, though occasionally 350 are obtained. When the amount of dust carried in the gases is considered, it is readily conceivable how there can be an accumulation between furnace lay-off periods that will seriously affect the draft. In one instance where, because of press of work, the connecting flue was not cleaned out during two periods when the furnace was down, the dust had filled the flue to more than a third of its cross-sectional area.

AIR LEAKAGE

Too much importance cannot be attached to keeping flue connections and boiler settings tight in order to minimize air leakage, the effect of which is to reduce

gas temperatures, decrease boiler capacity, and place an added burden on the fan unit.

The effects of air leakage and the possible improvement in results through its reduction may be shown by an example: One of the early boilers installed was with a small furnace which had been in operation for some time. The boiler was first put into service with no particular attention given to the tightness of existing flues, and a continuous run of 119 hours was started. For the first day or two the gas temperatures entering the boiler were very low, the temperature drop between the checkers and the boiler entrance being some 650 deg. This excessive cooling of the gases was found to be due to air infiltration through the length of the flue and an excessive amount of leakage at the stack by-pass valve. Nothing could be done toward remedying the latter defect, while the furnace was in operation, but flue leaks were stopped as far as possible without stopping the test. The reduction in these leaks increased the gas temperatures entering the boiler at the end of the run to approximately 1000 deg., as against 600 to 650 deg. at the start. The average gas temperature entering the boiler during this run was 855 deg.

The furnace was then shut down, the sources of air leakage more thoroughly gone over, and the leaky dampers repaired and sealed. A second run of 120 hours was then started, during which the average gas temperature entering the boiler, with the furnace conditions as nearly as possible like those in the first run, was 1153 deg. The loss between checkers and boiler was reduced to approximately 300 deg., most of which was due to a faulty reversing valve that could not be repaired without replacing.

The results of the two runs, showing the effect of reducing leakage, are as follows:

		Run No. 1	Run No. 2
Gas entering boiler	CO_2	8.08	10.49
	O	11.46	8.29
Gas temperautre entering boiler		855	1,153
Gas temperature leaving boiler		425	479
Draft boiler damper		3.99	3.77
Draft boiler inlet		1.85	1.85
Draft drop		2.14	1.92
Steam to fan engine (in terms of boiler horsepower)		35.7	28.1
Horsepower developed		132.4	200.2
Per cent of rated capacity		53.8	81.4

It is of interest to note from these figures that by minimizing the air leakage the draft loss through the boiler was reduced 0.22 in., which made possible a lower fan speed with a considerably higher economical rate for the fan turbine. A saving was effected of 7.5 b.-hp. for the fan drive, and there was an increase of 67 gross horsepower. Although this may be an extreme case, the enormous gains secured by reducing the air leakage to a minimum are obvious.

Air leakage through the flues can be minimized through proper design and location. Leakage through the boiler setting is reduced by the use of a compact design, well-erected and bricked in, with precautions to prevent leakage about all cleaning and dusting door frames. Much can be done by painting the settings with asphaltum paint.

CLEANING

As has been stated, the waste gases from open-hearth furnaces are very dirty; and because of the low temperatures, it is, perhaps, of more importance in this class of work than in coal-fired practice that the heating surfaces be kept clean. In the early installations, fears were expressed that dirt would have a tendency to stick to the tubes and be difficult, if not impossible, to remove. Experience has shown, however, that ordinary methods of dusting give perfectly satisfactory results.

In practically all plants now operating waste-heat boilers in connection with open-hearth furnaces, the boilers are dusted once in 24 hours. In one plant which operates eleven such boilers and in which the results are checked perhaps more closely than in the average steel plant, the engineers have concluded as the result of actual experience that it pays to dust every 8-hour shift.

Some figures showing the effect of dusting on exit-gas temperatures are of interest. In a certain plant a series of tests were run with cleaning intervals of 20, 10 and 6 hours. When the boiler was allowed to go 20 hours without cleaning, the reduction in gas temperatures after cleaning was 60 deg.; where the cleaning intervals were 10 hours, 50 deg., and where 6-hour intervals elapsed, the reduction varied from 10 to 30 deg. In a second plant, with larger boilers, after an undusted period of 24 hours, for an unchanged entering temperature the exit temperature was reduced 35 deg. by a thorough cleaning. In this instance, with the gas weight passing through the boiler, this 35-deg. reduction was equivalent to an increase of 22 hp. This increase in capacity would not, of course, hold over a period of 24 hours, but it would appear conservative to state that the 24-hour cleanings for such conditions would correspond to at least a net saving of 10 hp. as against 48-hour cleanings. At $40 a year per horsepower—a rough estimate of the yearly value—this would mean an annual saving of $400 per boiler.

The draft loss through a clean boiler will be less than through one not dusted; and while the decrease in load on the fan due to cleaning may not be great, it will at least be appreciable.

DAMPERS

Customary practice has been to use a vertical cast-iron sliding damper for the stack by-pass. Considerable difficulty has been experienced in keeping such dampers tight, and where the stack connection, rather than that to the boiler, is the direct connection, difficulty through warping has sometimes occurred. While as far as is known it has never been tried, it would appear that a damper similar in design to reversing valves warranted a trial, in order to reduce leakage at this point. Such a damper would automatically close the passage to the stack when that to the boiler was open, and vice versa, at the same time stopping all air leakage at a point where this might be excessive. It is possible that such a design of by-pass damper would require a small amount of cooling water, but the loss in heat to this water would, it is believed, be more than offset by the gain through reduced air leakage.

EXPLOSIONS

In the operation of open-hearth furnaces certain characteristic explosions are liable to occur during the reversal of gas valves. These vary in intensity from slight puffs to rather heavy explosions, and are caused by a mixture of fresh air with carbon monoxide which must pass off during the operation of reversal. Such explosions, often unnoticed with furnaces directly connected to a stack, become very evident where boilers are installed, and every effort is made to keep flues and settings tight. It was feared, and rightly, that with the installation of waste-heat boilers the heavier explosions might have a destructive effect on the boiler settings and connecting flues. For this reason particular attention should be given to proper buckstay construction, and an ample number of explosion doors should be furnished to relieve the pressure within the setting, should explosions take place.

A thorough investigation of the trouble from explosions showed that by a proper system of reversing-

valve operation the difficulty would be practically overcome; certainly to an extent where sufficient and properly designed explosion doors would obviate the possibility of wrecking or injuring the settings.

A method of reversal that experience has shown gives satisfactory results is as follows: Fig. 2 shows in diagrammatic form a typical layout of checkers, valves, flues, stack and boiler inlet, the valves being indicated by *A* to *H*, inclusive, and the checkers *I* to *L*, inclusive.

Assuming the gases from the open hearth are passing

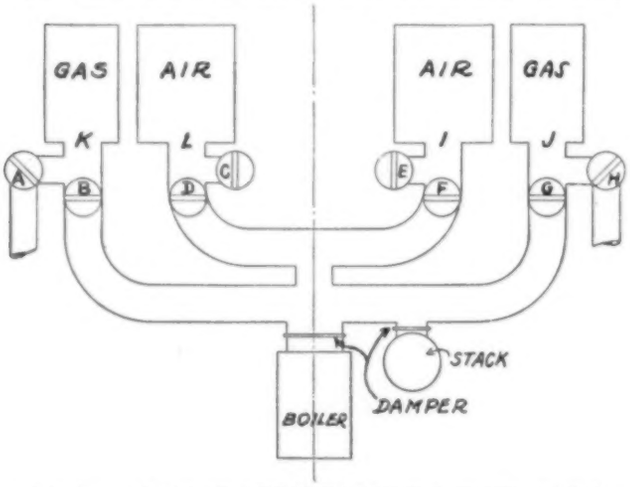


FIG. 2—LAYOUT OF CHECKERS, VALVES, FLUES, STACK AND BOILER INLET

through the gas checkers *J* and the air checkers *I*, the order of operation is:

1 Turn off steam to producers
2 Close air stack valve *F*
3 Close gas inlet valve *A*
4 Close air inlet valve *C*
5 Open gas stack valve *B* (producer gas held in gas checkers *K* now passed to boiler)
6 Close stack valve *G*
7 Open air inlet valve *E* (air now admitted to the furnace to give proper combustion upon the opening of the gas valve)
8 Open gas inlet valve *H*
9 Open air stack valve *D*
10 Turn on steam to producers.

The essential feature in such a sequence of operation is, of course, to avoid opening the stack valves from gas and air checkers simultaneously, or nearly enough together to allow the hot producer gas and air from the checkers to mingle and ignite within the flues or boiler settings. In this system of reversal the air stack valve *D* is opened a sufficient interval after the opening of the gas stack valve *B* to allow the gas pocketed in the checkers *K* to pass away and mingle with the existing gases before the hot air from the checkers *L* is admitted to the flues through opening the valve *D*. In reversing the operation, similar precautions should be taken respecting gas stack valve *G* and air stack valve *F*.

In a plant where this system was followed, explosions were reduced from approximately 40 per day (about one each two reversals), varying in intensity, to 4 in 411 consecutive reversals covering a period of five days, and of these 4 but 2 could be called heavy and were directly traceable to a leak in a hydraulic valve which, through the operation of the ram, caused the gas valve to unseat.

This system may be modified for different valves and flue arrangements, but the time between opening the stack valves and gas and air checkers is the important point.

Another system used is one of interconnected valves, sets of valves being operated simultaneously. Perhaps the best method would be a combination of the two; that is, valves interconnected to assist in manipulation but so arranged that the first order will be followed. The connections should be designed so that sufficient time will elapse between opening the stack valves and gas and air valves to make impossible the mingling of hot producer gas and air.

SAVINGS

Great savings have been made possible by the installation of waste-heat boilers with open-hearth furnaces, and some approximate figures are of interest.

There have been installed, or ordered, over 90,000 rated boiler horsepower for this class of waste-heat work alone. These boilers are set with over 190 open-hearth furnaces, the annual total production of which is considerably in excess of 9,200,000 tons of steel. Experience has shown that through the use of waste-heat boilers the net cost of production of this material is reduced from $0.20 to $0.25 per ton, which would mean a net annual saving for the production weight given above of $1,840,000, using the lower figure.

From another aspect: A conservative estimate of the power delivered by the boilers in this class of work through a year's operation would be 60 per cent of their rated capacity, or 54,000 horsepower. The value of a boiler horsepower in a steel mill varies widely with any number of factors, and ranges from $35 to $50 per year. On the basis of the lower figure, which is certainly conservative, the value of the 54,000 hp. produced would represent a saving of $1,890,000.

Waste-heat boilers, because of their special design, are more expensive than coal-fired boilers, and the expense is increased by the cost of fans, connecting flues, and structural material. The latter expense, of course, is the greatest where boilers are installed with existing furnaces. Regardless of this increased cost, however, the return on the investment is such as beyond question to warrant the expenditure. Mr. Bacon, in the paper to which reference has been made, states that this return on the investment is 60 per cent or over, and recent experience would seem to indicate that this figure is conservative.

In the early days of this work, open-hearth steel furnace operators were fearful that the installation of waste-heat boilers with their fan units would seriously affect the operation of the furnace, and that the production would be cut down, the cause of such reduction being in the necessity of longer heats. By actual experience just the contrary was found to be true, and furnaces equipped with boilers showed a decrease in time of heats.

In one instance a 35-ton furnace equipped with a waste-heat boiler and fan was set in a line with five other furnaces not so equipped. The operation of all furnaces was alike and the size of the heats the same. Over a period of six days the average time of heat for the furnace equipped with the waste-heat boiler was 9.17 hours, while the average for the other five furnaces was 11.17 hours.

Eight different sets of furnaces in all were investigated in connection with the saving in heat length. These furnaces varied in rated capacity from 35 to 75 tons, the actual production ranging from 40 to 87 tons per heat. The normal length of heat in the furnaces connected direct to the stack, from records secured previous to the installation of the waste-heat boilers, averaged, for the 8 furnaces, 12.1 hours. The average

length of heat for the same furnaces, after the installation of the waste-heat boilers, was 10.8 hours, the saving in time varying in individual furnaces from but a few minutes to 2.9 hours. The total tonnage per heat of the eight furnaces in question was 507 tons. The increased tonnage of the 8 furnaces due to the decrease in heat length would amount to 42,000 tons per year, or approximately a 12 per cent increase in the total tonnage of these furnaces.

There is a further saving due to the use of the induced-draft fan with which these waste-heat boilers are equipped. This is in the increased life of the furnace and results from the fact that a fan makes it possible to run economically a heat from a furnace which under ordinary natural-draft conditions would take so long that it would not pay.

Cement Kilns

Strictly speaking, the use of waste-heat boilers in the cement industry is not new. The number of installations, however, has been extremely small, and there appear to have been several reasons for the non-development of such boilers in this field.

It was feared that the installation of a boiler would seriously affect the successful operation of the kilns, though possibly this was not as important a factor in cement practice as in some other work; and in common with other waste-heat installations, there was opposition to the installation of mechanical draft because of the power required. There was a decided feeling that a satisfactory arrangement of kiln and boiler could not be worked out and that, because of the amount of dust carried by the gases, boiler difficulties would develop and maintenance costs be high. Further, with the improvement in kiln design (the first commercially successful rotary kilns were used in this country in 1893) and the tendency toward increased kiln length, gas temperatures were lowered to a point where, as in open-hearth practice, it was not considered practicable, if at all possible, to generate steam economically.

Several attempts were made to utilize the heat in these gases through economizers, but such a small proportion of the total heat was reclaimed in this way, and so much difficulty developed through the choking up of the economizers with dust, that such attempts were soon abandoned.

Prof. R. C. Carpenter, Mem. Am. Soc. M.E., in the Sibley Journal of Engineering, March, 1904, describes what is believed to be the first installation of a waste-heat boiler with a rotary cement kiln. This was made in 1902 at the plant of the Cayuga Lake Cement Co., a Wickes boiler of 3065 sq. ft. of heating surface being connected to two kilns 7 ft. 6 in. and 6 ft. 6 in. in diameter by 60 ft. long; each kiln having a capacity of approximately 150 bbl. per day. The waste gases from these kilns were passed through the boiler and economizer and, in addition, coal was ordinarily fired on auxiliary grates. The approximate results obtained from this boiler are given in Table 2. This boiler was removed several years ago because of the necessity for using the space it occupied for other purposes.

In a paper, Pulverized Coal Burning in the Cement Industry,[1] Professor Carpenter states that, as far as he knows, the only successful installation of waste-heat boilers in the cement industry was at the Kosmosdale plant of the Kosmos Portland Cement Co. A rather thorough investigation of this subject showed that in the early part of 1915 there were at least two other plants utilizing waste kiln gases for steam generation, and securing results that were considered satisfactory. These plants are the Burt Portland Cement Co., Bellevue, Mich., and the Sandusky Portland Cement Co., at Dixon, Ill.

[1]Trans. Am. Soc. M. E., vol. 36, p. 85.

TABLE II—RESULTS OF TESTS OF WASTE-HEAT BOILERS FOR CEMENT KILNS

Test Number	1	2[1]	3[1]	4
Plant	Cayuga Lake Cem. Co	Sandusky Port C m. Co.	Burt Port. Cem. Co.,	Louisville Cem. Co.,
Location	Ithaca, N. Y.	Dixon, Ill.	Bellevue, Mich.	Speeds, Ind.
Size of kilns, ft	.....	8×100	7×60	10×150
No. of kilns connected to boiler	2	1	2	2
Boiler	Wickes	Stirling	Stirling	B. & W.
Heating surface, sq. ft	3,065	3,200	3,200	15,330
Gas weight, lb. per hr	37,749	52,300	53,000	183,700
Gas per hr. per sq. ft. of h.s., lb	12.6	16.3	16.6	12.0
Temperatures:				
Gas entering boiler, deg. Fahr	1,800[2]	1,300	1,400	1,400
Gas leaving boiler, deg. Fahr	660	600	700	423
Drop in temp., deg. Fahr	1,140	700	700	977
Draft at boiler damper, in	1.2[3]	0.45	0.30	6.63
Draft at boiler inlet, in	.....	0.06	0.03	0.81
Draft loss, in	.....	0.39	0.27	5.82
Gross hp. developed	264	275	278	1,346
Per cent of rated capacity	88	85.9	86	88
Approximate transfer rate (R)	3.19	4.85	4.19	6.01

[1]Results very approximate.
[2]Optical pyrometer.
[3]Draft at economizer outlet.

The installation at the Kosmos plant consists of four Wickes boilers rated at 250 hp. each, each connected to a kiln 7 ft. in diameter by 80 ft. long with a capacity of 340 bbl. per day. The gases leaving the kilns are given a considerable horizontal travel, then a downward path and finally an upward travel, this direction of flow being with the idea of precipitating dust in the downward pass. These boilers are fired with coal on flat stationary grates, and the waste gases are brought into the side of the boiler setting at a point somewhat above the furnace arch.

The installation at the Burt Portland Cement Co. plant consists of four Stirling boilers rated at 320 hp. each. One boiler is set in connection with two kilns 7 ft. in diameter by 60 ft. long, the capacity of each kiln being approximately 225 bbl. per day. These boilers utilize waste gases alone. This installation is more or less typical of the four described, and the general arrangement of boiler, flue and kilns is shown in Fig. 3.

The Sandusky installation consists of seven Stirling boilers, each of 320 hp., each boiler being connected to a single kiln 8 ft. in diameter by 100 ft. long with a rated output of 540 bbl. per day. These boilers were

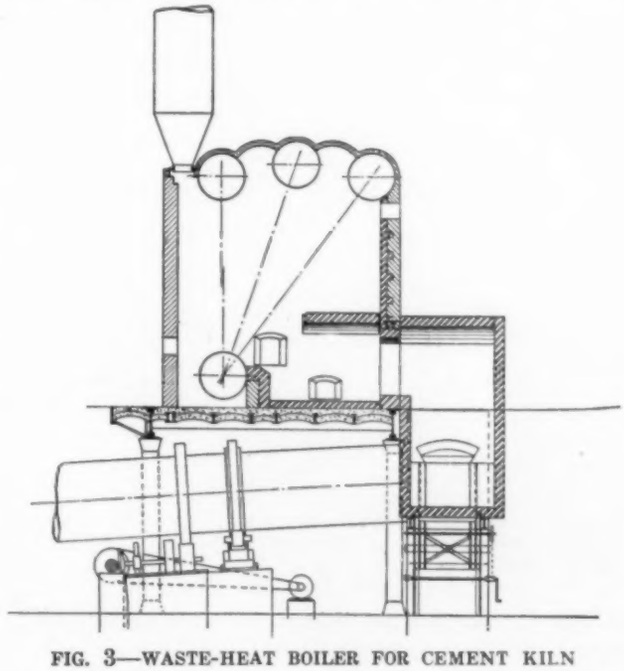


FIG. 3—WASTE-HEAT BOILER FOR CEMENT KILN

originally designed for coal in addition to waste heat. Because of low draft available it was found impossible to burn coal economically, and for the past few years firing and ashpit doors have been bricked up and waste heat used alone.

The four installations described were alike in that low gas velocities were used. In the Cayuga Lake and Kosmos plants it is true that induced-draft fans were installed, but this was because economizers were included in the units and not because of any high draft loss through the boiler. In the Burt and Sandusky installations, where the gases were given three passes over the heating surfaces as against two at Cayuga and Kosmos, the baffle openings were considerably larger than standard to minimize the draft loss. As far as can be found, the maximum loss through any of the boilers described was 0.35 in., and it is interesting to compare this loss with that through the modern boiler in this practice.

The exit-gas temperatures from all four of the installations were high, and in the case of the Burt and Sandusky plants enabled a reasonable height of stack to give ample draft for proper kiln operation. The gases leaving the kilns were at temperatures varying from 1500 to 1800 deg. and from 1300 to 1650 where entering the boilers. The generation of sufficient steam to warrant the investment in waste-heat boilers was not particularly difficult with these temperatures. With an increase in kiln length, however, and perhaps with the improvement in burning coal in the kilns themselves, these exit-gas temperatures were reduced very appreciably, and gas temperatures at a point corresponding to a boiler inlet were lowered to around 1150 or 1200 deg., a fact that unquestionably delayed the development of waste-heat boilers in this work.

Success with the low-temparture gases from open-hearth furnaces indicated possibilities in the cement field that aroused considerable interest in the industry and led, in 1915, to the first installation of the modern design of waste-heat boiler with rotary cement kilns. This was made at the plant of the Louisville Cement Co., Speeds, Ind. It consisted of a Babcock and Wilcox boiler containing 15,300 sq. ft. of heating surface and 1382 sq. ft. of superheating surface. This boiler is connected to two kilns 10 ft. in diameter by 150 ft. long. The nominal capacity of each of these kilns was considered at the time of the boiler installation approximately 875 bbl. per day, but with improved kiln operation, and because of the ability to remove the products of combustion from the kilns through the installation of the induced-draft fan, this capacity has reached an actual output of 1300 bbl. of cement per kiln per day. The boiler is equipped with a turbine-driven fan capable of handling the gases from the two kilns when operated at their maximum capacity, and to furnish a suction sufficient to overcome the resistance through the boiler, through the settling chambers and connecting flues, and still leave ample at the kiln outlet for proper operation. The approximate arrangement of this boiler with its connecting flues and kilns is shown in Fig. 4.

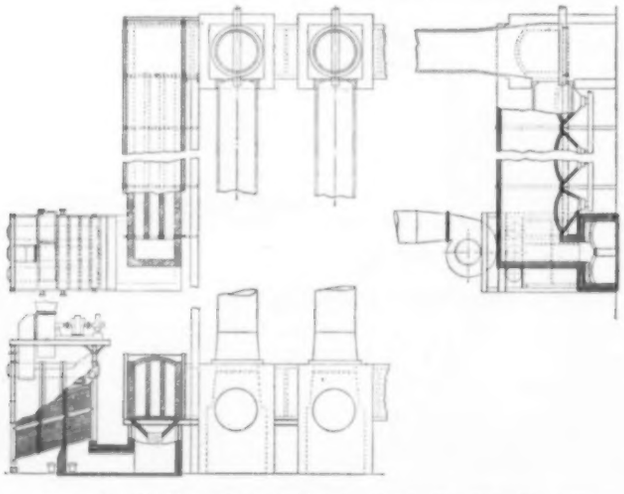


FIG. 4—WASTE-HEAT BOILER, CEMENT KILNS AND CONNECTING FLUES

The results obtained from some of the early boilers and those now being obtained from the Louisville installation are given in Table 2. Unfortunately, the data from which the second and third sets of figures are computed are not as complete as could be wished. This is due to the fact that in a number of the tests available coal was burned in addition to the waste gas passing through the boiler, and an attempt made to divide the power developed between the coal and waste gas. A study of different tests, however, some of which were on waste gas alone, enabled us to approximate these results closely, and the figures given are probably correct within reasonable limits. For purposes of comparison with the results secured from the modern waste-heat boiler, they are sufficiently accurate to indicate the enormous gains through the use of such a design.

The gas temperature entering the boiler in Test No. 4 is perhaps higher than ordinarily could be expected with kilns of this size, and until the period during which this particular test was run this temperature probably averaged only slightly over 1200 deg. However, the output of the two kilns during this test was at a point which has since been maintained or bettered, and the temperature in Test No. 4 is representative of present and future practice for these kilns. It would appear that the limiting factor in kiln output, and hence, as affecting boiler capacity, in entering-gas temperatures, is governed by the maintenance cost of the kiln lining.

That the fears which have retarded the development of waste-heat boilers in the cement industry, as outlined at the beginning of this section, have been more or less groundless, is shown by the results secured at the Burt and Sandusky plants over a period of eight years, and to a more marked degree by the very great success, over a period of eighteen months, of the modern design of waste-heat boiler at the Louisville plant.

DRAFT

The installation of waste-heat boilers has not affected kiln operation. At the Burt and Sandusky plants, stacks 135 and 150 ft. high respectively give sufficient draft to overcome the frictional resistance through the boilers and allow sufficient for good kiln operation. The baffle openings in these boilers, that is, the gas-passage area, are, as stated, considerably greater than in coal-fired practice, and the draft loss for the weight of gas passing through the boilers is far less than the loss which would occur with standard areas of gas passage. Further, the gas temperature leaving the boilers is so much higher than is found for any reasonable rating for coal-fired boilers, that the draft suction for a given height of stack is appreciably increased.

At Cayuga Lake and Kosmosdale, induced-draft fans were installed. The boilers at these plants were of a design giving a low draft loss, and the fan installations were due to the economizers. These increased the total draft requirements and the gases were sufficiently cooled by the economizers to decrease the draft for the given stack height well below that obtained at the Burt and Sandusky plants. The draft at the

fan inlet, however, at neither of these plants exceeded 1½ in.

The draft loss through the boilers at the Louisville plant is high. The fan installation, however, running well below its maximum capacity, satisfactorily handles the maximum amount of gas from the two kilns and gives ample draft at the kiln throat for a production greatly increased over that secured before the boiler and fan were put into service. While the increase in production is due primarily to changes in kiln operation and improvements in the methods of burning coal in the kilns, the added draft available through the use of the fan and the ability to handle greatly increased gas weights have unquestionably been of assistance in making this greater production possible.

When the first installations of waste-heat boilers utilizing the principles of high gas velocity and necessitating mechanical draft were under consideration, the operators, as stated, had a strong feeling against the use of fans because of the power required. Experience has shown, however, that with a turbine-driven fan unit the exhaust is just about sufficient to heat the feed of the boiler it serves. It is to be remembered, too, that with all the kilns in a plant equipped with waste-heat boilers, such boilers will furnish practically the entire power required, and the exhaust from the fan turbines will give the only means of feed-water heating.

CLEANING

No difficulty has been experienced in keeping the boilers in this service externally clean. In all but one of the plants investigated the dust has been found to be very light. In the absence of water there is no particular tendency for this dust to stick to the tubes and it may be readily blown off with an ordinary cleaning lance, using either air or steam. Where steam is used, it is perhaps well that this be superheated to minimize the possibility of wetting this dust.

At the Burt plant the practice is to dust with air every 12 hr. During dusting periods the by-pass damper to the stack is partially opened to reduce the draft at the boiler damper with the object of settling as much dust as possible within the setting and connecting flue. At this plant the greater part of the dust was deposited on the level floor in the furnace under the arch, Fig. 3, in the pocket behind the mud drum and on the baffle shelves, there being but little dust that collects on the tubes.

At the Sandusky plant the boilers are dusted with air every 6 hr. Here the boiler is not by-passed when dusting and a considerable amount of dust is blown up the stack at such times. One of the boilers at Sandusky has been equipped with stationary blowers, all dusting doors except those necessary for cleaning out the setting having been bricked up. As far as known, these blowers have given satisfactory service. It is to be recommended that where steam is the dusting medium, with such stationary blowers every precaution be taken to prevent condensation from remaining in the piping system.

At the Louisville Cement Co. plant the boiler is dusted with superheated steam every 12 hr. There has been no difficulty experienced in keeping the boiler tubes clean, and while there has been some tendency toward the dust bridging over on the superheater tubes, this is something that could be readily remedied by a change in the tube arrangement. It is interesting to note that in this boiler dust forms as an inverted V on the tops of the boiler tubes within half an hour after dusting, and that the increased deposit after this half-hour period until the next dusting interval is almost imperceptible. This is unquestionably due to the high draft suction within the setting; that is, the high gas velocity actually has a scouring action on the tubes.

LEAKAGE

As in open-hearth work, it is imporant in cement waste-heat practice to reduce air leakage to a minimum with a view to increasing temperatures and boiler capacities and reducing the load on the fans. The main source of leakage in this class of work is at the end of the kilns where the rotary enters the dust chamber that ordinarily serves as the stack base. Experiment has shown that leakage at this point can be reduced to a negligible quantity by the use of a properly designed seal ring. The effect of the air leakage on the weight of gas that must be handled by the fan is indicated by the gas analysis. What can be done by way of reducing leakage and increasing gas temperatures is shown in Table 3, which gives

TABLE III—RESULTS OBTAINED BY REDUCING AIR LEAKAGE

		Plant No. 1		Plant No. 2		Plant No. 3	
		Conditions as Found	Leakage Reduced	Conditions as Found	Leakage Reduced	Conditions as Found	Leakage Reduced
Gas Analysis at Stack Base	CO_2, per cent.	11.60	14.44	13.9	21.3	15.43	19.55
	O_2, per cent.	11.85	8.86	10.4	4.3	7.99	2.87
	CO, per cent.	0.00	0.00	0.0	0.0	0.00	0.00
Gas temperature at stack-base, deg. Fahr.		952	1242	1100	1480	1234	1360

results secured in the investigations of three different plants, the first figures showing conditions of operation as found and the second those after an intelligent effort has been made to better these conditions from the standpoint of a waste-heat boiler.

SAVINGS

As in most classes of waste-heat work, the greatest saving is in the value of power produced by the steam generated.

The measure of the efficiency of the cement plant is ordinarily the pounds of coal burned per barrel of cement, though presumably this should be corrected to a B.t.u. basis. The amount of coal per barrel depends upon the class of coal, the efficiency of the steam generators and prime movers, and the class of operation in the plant. The coal per barrel is divided into that actually burned in the kilns, which figure usually includes the amount required for drying the coal previous to pulverizing, and that burned in the power plant. In most plants an amount of coal, approximately 7½ lb. per barrel, is used in drying the rock, and this should be included in the total. The installation of a waste-heat boiler does not of necessity reduce the coal per barrel of cement burned in the kiln, but it is obvious that any steam generated through the use of the waste gases from the kiln results in a reduction of the coal that must be burned in the power plant.

Possible savings through the utilization of the available heat in the gases leaving the kiln are indicated by the results secured at the Burt and Sandusky plants where boilers are not of the most highly developed waste-heat design, and to a much greater extent by the results obtained at the Louisville plant, where the boiler is more truly representative of such design.

Unfortunately, no figures are available from the Burt or Sandusky installations as to the coal burned

per barrel of cement in the power plants previous to the installation of waste-heat boilers, but the savings are seen in the proportion of the total steam generated by the waste-heat boilers.

At the Burt plant approximately 60 per cent of the total steam requirements is furnished by the four waste-heat boilers. The coal burned under the direct-fired boilers amounts to approximately 40 lb. per barrel of cement. On this basis, if the waste-heat boilers were not installed it would be necessary to burn 100 lb. of coal per barrel of cement in the power plant, a figure which is perhaps slightly high, as the 40 lb. per barrel now burned includes sufficient coal for banking two 300-hp. direct-fired boilers, in addition to the one actually operated. At Sandusky the waste-heat boilers develop approximately 65 per cent of the total power required. The coal burned in the direct-fired boilers is approximately 30 lb. per barrel of cement, on which basis it would be necessary to burn approximately 87 lb. per barrel in the power plant were no waste-heat boilers installed.

As stated, the possibilities of saving in this work through the use of waste-heat boilers are most clearly shown by the results secured at Louisville. Here the boiler is of the most modern design, and actual coal figures are available before and after the boiler installation. In addition to the two 150-ft. kilns attached to the waste-heat boiler, there are two kilns 8 ft. x 125 ft. There are also two kilns 7 ft. x 100 ft., although these are not at present operated. The coal burned per barrel of cement is some 15 lb. greater in the 125-ft. kilns than in the 150-ft. kilns. The plant is operated about nine months in the year.

In 1914, before the installation of the waste-heat boiler, the average coal consumption per barrel of cement for the total plant output was 191.2 lb., of which 99.5 lb. were burned in the kilns and 91.7 lb. in the power house.

The waste-heat boiler was installed in the early part of 1915 and was put into service May 12, although the plant was started in this year in March. The total coal consumption for the 1915 operation was 162.3 lb. per barrel of cement, of which 104.7 lb. were burned in the kilns and 57.6 lb. in the power house. The increase in the coal burned in the kilns per barrel over 1914 was due partly to a greater kiln output and partly to a larger proportion of the total production being from the smaller kilns. The decrease in coal burned in the power house is not representative of what could be secured for the reason that the figures are for the entire year's operation, while the boiler was not put into service for some two and one-half months after the plant was started.

For the months of March and April, 1916, the total coal consumption was 150.9 lb. per barrel, 104.05 lb. being burned in the kilns and 46.85 lb. in the power house. The decrease in the power-house consumption here below the 1915 figures is due to the fact that the waste-heat boiler was in operation continuously and because the large kilns were operated at a rate to give a greater capacity from the boiler than was secured in 1915.

For one week in May, 1916, conditions approached those that will be secured at this plant when the additional boiler, a duplicate of the present installation, is installed with the two 125-ft. kilns, and possibly with one 100-ft. kiln also connected. During this week the total coal consumption per barrel of cement was 123.5 lb., 94.7 lb. being burned in the kilns and 28.8 lb. in the power house. The reduction in the coal per barrel in the kilns was due to the fact that only the 150-ft. kilns were in operation. As in the case of the 1915 figures, the coal per barrel burned in the power house does not represent what may be expected after the installation of the second waste-heat boiler, for, while the kilns were operating at a rate of 1145 bbl. each per day, or 2290 bbl. for the two kilns, due to the amount of clinker on hand, the grinding machinery was being operated at the rate of 3500 bbl. per day. With the second boiler in operation it would appear conservative to believe that the coal consumption in the power house for all kilns operating will be less than 15 lb.

For the purpose of figuring savings, assume that the figure 28.8 lb. per barrel will be burned in the power house. This would represent a saving of 62.9 lb. of coal per barrel of cement over the 1914 figures. For a production of 3500 bbl. per day, a conservative estimate for the Louisville plant, this would represent, for nine months' operation, some 29,000 tons per year. A boiler horsepower is valued at this plant at approximately $25 a year, a figure which, in view of the operating year and the cost of coal, is conservative. On the basis of this value, the steam generated as shown in Table 2 is worth $33,850 a year.

In addition to the saving represented by the power developed, there is an appreciable saving in the amount of dust reclaimed from the flue connecting the kiln or kilns to the boiler and from the boiler setting proper. This reclamation is ordinarily fed over again to the kilns with the raw material. That such a saving exists is apparent upon a visit to a cement plant equipped with waste-heat boilers, where it is seen that the deposit on surrounding property is appreciably less than in plants where no boilers are installed.

At the Burt plant, where the boilers are dusted once in 24 hours, approximately 2000 lb. of dust are reclaimed from each boiler setting per day and about 8000 lb. from the flues connecting two kilns to one boiler. This represents about 3 per cent of the total output of the kiln.

At the Sandusky plant, where the flue arrangement is not such as to give as good a settling action as at the Burt, about 4000 lb. are reclaimed from the boiler setting and connecting brickwork per day, or 1¼ per cent of the total output. At Sandusky, as stated, the boiler is not by-passed in any way during dusting intervals and an appreciable amount is blown up the stack.

At Louisville the flue connecting the two kilns to the boiler is long and is especially designed with the object of settling out as much dust as possible before the boiler is reached. This flue is equipped with hoppers at intervals along its length which are emptied each day and the material returned by conveyors to the kilns. The first boiler installed had settling pockets beneath the first pass and beneath the second and third passes, which are cleaned out by hand every few days. The second boiler installed is raised sufficiently to have hoppers beneath the various passes, the pockets to these hoppers being emptied as are the flue hoppers.

The amount of reclamation at the Louisville plant is such as to have reduced the raw material fed to the kilns per barrel of cement from 610 to 586 lb., a saving due to the dust collected of 3.9 per cent.

The above savings do not represent an increase over the amount reclaimed in plants where no boilers are installed, for at such plants there is a certain amount of material taken out of the collecting chambers which serve as stack bases. The figures given, however, probably represent a saving of at least 100 per cent more in the case of the kilns equipped with boilers over kilns not so equipped.

Copper Furnaces

The copper furnaces with which waste-heat boilers have been installed may be classed under two general heads: Smelting furnaces (matte furnaces) and re-

fining furnaces. In the United States the smelting furnaces are in localities more or less accessible to the copper mines, while the refining, with the exception of plants at Great Falls, Mont., and Tacoma, Wash., is done entirely on the Atlantic seaboard.

Smelting furnaces and refining furnaces are fundamentally the same in design, though for metallurgical reasons dimensions of the two classes and individual furnaces in the two classes are varied considerably.

Copper-smelting Furnaces. Because of the high temperature of the gases leaving copper-matte furnaces, it was but natural that the attention of engineers was early drawn to the utilization of such heat for steam generation.

At the time of the first installation such few waste-heat boilers as were in service in any class of work were single-pass boilers utilizing high-temperature gases and operating in such a way as to interfere in no manner with the working of the primary furnace. It is probably because of this fact that the effect of the boiler installation on furnace operation was apparently given no particular attention at the time of the purchase of the first boilers for this work.

The Anaconda Copper Mining Company purchased, in 1903, eight Stirling boilers, rated at the time at 375 hp. each, for installation with reverberatory smelting furnaces. The boilers were not equipped with firing fronts or grates, but were erected with the standard baffle arrangement for this type of boiler. As soon as the boilers were put into service it was found that the resistance to the gases through the boiler was so great as to affect appreciably the operation of the furnace, and the matter proved so serious that at one time the removal of the boilers was seriously contemplated. It was found, however, that by removing all baffles, the gases passed through the tubes without undue restriction, and that there was no interference with the operation of the smelting furnace.

The temperature of the gases entering the boiler averaged approximately 2200 deg. After the removal of the baffles, it was found that the temperature leaving the boiler was considerably in excess of 1000 deg., and in order to diminish this temperature and utilize a greater proportion of the heat, a second boiler, rated at 300 hp., and also without baffles, was placed in the rear of the first boiler, that is, the two were set in tandem. The approximate arrangement is shown in Fig. 5. Under these conditions, for an average gas temperature of 2200 deg. at the entrance of the first boiler, the temperature when leaving the second boiler was found to vary from 620 to 720, the average being approximately 680 deg. It was determined by test that the first boiler developed 470 hp. and the second 100 hp., a total of 570 hp., or, on the basis of 10 sq. ft. per horsepower, 86 per cent of the rated capacity of the combined boilers. It is interesting to compare the results obtained from the second boiler, where the entering temperature was somewhat over 1000 deg., with the results secured from the modern waste-heat boiler in open-hearth steel practice, where the entering temperature is in certain installations the same. As against 33 per cent of nominal rating in the case of the copper-furnace waste-heat boiler, in steel plants, for a corresponding entering temperature, some 60 per cent of nominal rated capacity is developed with the modern boiler.

The flues in the Anaconda plant were so arranged that one pair of boilers could be cut out and all of the gases from two furnaces be passed through the next set. Under such conditions the temperature of the gases leaving the second boiler varied from 800 to 950 deg., the average being approximately 900 deg. The first boiler, with two furnaces connected, was found to develop 776 hp. and the second 194 hp., a total of 970 hp., or 143 per cent of the combined boilers. While this is considerably over rating for the amount of surface installed, it is interesting to compare the capacity and the exit-gas temperature with the results secured in utilizing waste gases from coke ovens (Table 5), where the temperatures of the gases entering the boiler are considerably lower than in copper-furnace work and the weight of gases approximately the same.

The high boiler-exit temperature with two furnaces connected to a pair of boilers, probably explains why double the amount of gas could be handled through the boilers without interfering with furnace operation.

The engineers of the Anaconda plant were more or

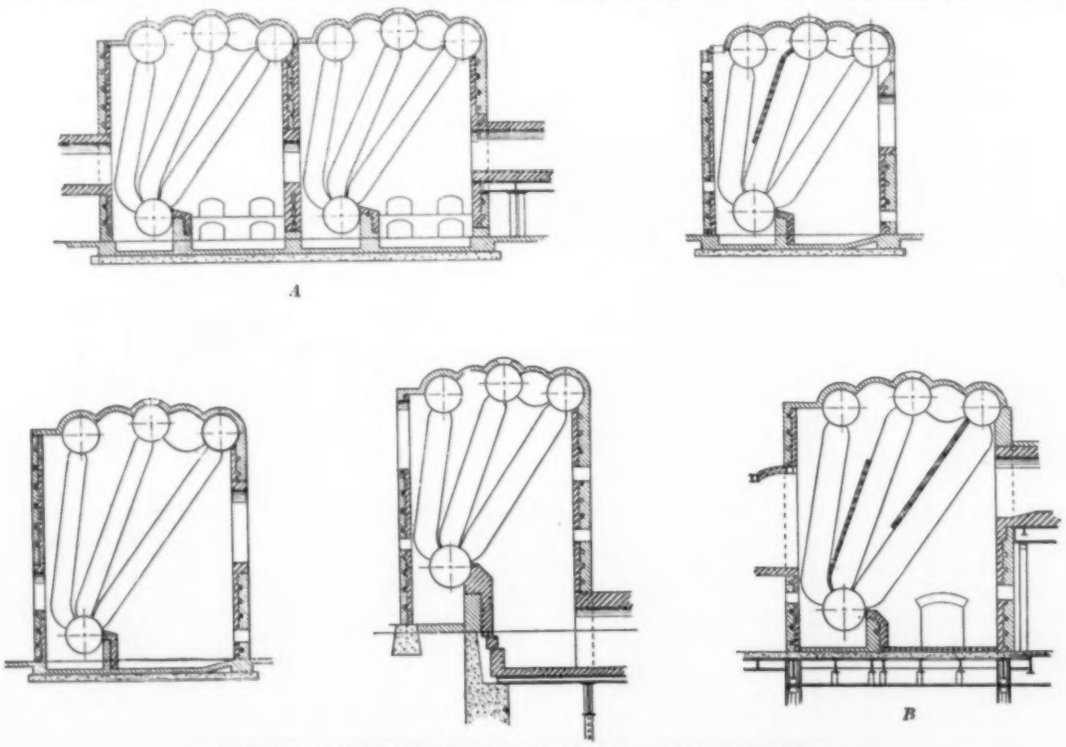


FIG. 5—TYPICAL WASTE-HEAT BOILERS FOR COPPER FURNACES

less directly connected with a number of copper-smelting plants, and naturally influenced largely the selection of the type of boiler to be used in this class of waste-heat work. The theory of such selection, based on the Anaconda results, apparently was the furnishing of ample gas-passage area. The operation of smelting in copper furnaces requires large quantities of coal. Because of the nature of the furnaces, air leakage was excessive. These factors led to enormous gas weights that had to be handled, and in the absence of mechanical means of draft, the furnishing of large gas-passage areas through the boilers was the sole means of keeping the draft loss within limits in which satisfactory furnace operation could be secured.

Acting on this theory, a great number of installations was made of boilers set in tandem, as at Anaconda, or single boilers of large cross-sectional area. Some of these single boilers were partially baffled, while others were entirely without baffles. In some few cases where single boilers were used, superheaters were placd in the outlet connection from the boiler to reduce exit temperatures and increase the combined capacity. Some typical settings of such boilers are shown in Fig. 5.

In 1905 or 1906 an installation was made at the Cananea Copper Company, which differed in general arrangement from what was the common practice at the time, as described above, and was a step in the direction of the more modern design of waste-heat boilers. Here, instead of using single boilers or boilers in tandem, three Stirling boilers rated at 314 hp. each were set in parallel, the gases from a single reverberatory being divided and passed simultaneously through all of the boilers. With this arrangement, each boiler was handling what might be considered a normal amount of gas at an entering temperature approaching that of coal-fired practice, and under such conditions baffle openings could approximate those standard in coal-fired work without excessive draft loss or interference with furnace operation.

The practice at the Cananea plant is described in a paper entitled experiments in Reverberatory Practice at Cananea, Mexico, presented in 1909 before The Institute of Mining and Metallurgy, London, by Dr. L. D. Ricketts.

The success of this first installation at Cananea was such that two additional Stirling boilers were purchased in 1906. Three Aultman and Taylor boilers which were available were also reset for waste-heat work at this time, the seven boilers being connected to a common header flue receiving the gases from two reverberatory furnaces. The general arrangement of furnaces, flues, boilers, economizers and stack is shown in Fig. 6.

The operators and designers of this plant feel that because of the greater tendency of dust to lodge on horizontal than on the more nearly vertical tubes, the latter design of boiler is better suited to this particular work. This feeling is hardly borne out by experience in the cement industry, where the waste gases carry as much if not more dust than in copper-furnace practice. It seems probable that if the modern theory of high gas velocity were used in copper-furnace waste-heat boilers, there would be the same tendency for this velocity to keep the tubes "scoured" as was noted in the cement-kiln waste-heat boilers at Speeds, Ind.

Difficulties were experienced at Cananea through the clogging of the economizers with dust. This interfered seriously with the draft and hence with the furnace operation. Since mechanical draft was not used in this branch of waste-heat work, the designers of the plant omitted economizers in later installations.

The baffle openings in the Stirling boilers at the Cananea plant are approximately what are installed for standard coal-fired practice, and the baffling in the Aultman and Taylor boilers is standard. In some of the later installations where boilers were set in parallel the boilers were but partially baffled.

From 1906 to the present time there has been no radical change in the design of the boiler above described for utilizing the waste gases from copper-smelting furnaces. In the large number of installations made during this time all three arrangements—the single unit, the two units in series, and the two or more units in parallel—have been used, though perhaps the single large unit per furnace has been the most popular. The

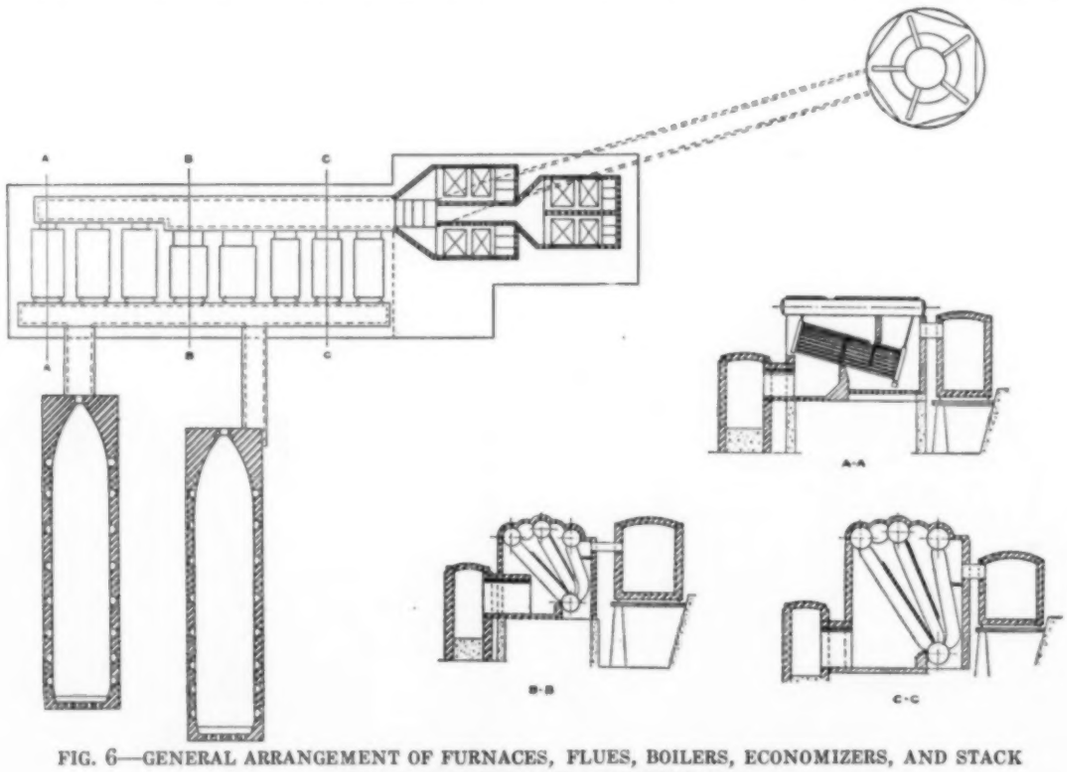


FIG. 6—GENERAL ARRANGEMENT OF FURNACES, FLUES, BOILERS, ECONOMIZERS, AND STACK FOR COPPER-FURNACE INSTALLATION

amount of baffling, that is, the gas-passage areas in the different installations, apparently has been governed largely by the individual ideas of the engineer in charge of the installation.

In the early installations it was common practice to install 12 sq. ft. of heating surface per horsepower to be developed. The tendency in later installations has been to increase rather than decrease this ratio, and many copper-plant engineers are advocating the installation of 20 sq. ft. per horsepower required from the class of boilers in general use for this work. A comparison of this allowance with that amount necessary in modern design of waste-heat boilers is of interest.

In the early installations in this work, serious fears were expressed that because of the great quantities of sulphur in the gases from smelting furnaces the life of the boiler would be short. These installations were carefully watched on this point over a considerable period, and as far as is known no trouble has arisen from this source; and there has been no action of the sulphur in the gases on the tubes except in such instances where, because of leaks or other causes, moisture has been present to form sulphuric acid. To minimize the possibility of moisture finding its way into the setting, it has been the general practice to use air for dusting tubes rather than steam.

It was noticed, however, in the early installations that there was a tendency for small lumps or nodules of solids to form on the surface of the tubes, particularly where the gases first impinged. These nodules, while they apparently had no action on the metal of the tubes, were very difficult to remove with an air jet, and for that reason provision was always made to give access to the heating surface so that this deposit could be removed with a wire brush. This last factor unquestionably had a considerable bearing on the omission of baffles for this work.

With smelting furnaces the only saving due to the utilization of waste gases is the steam generated. The amount of this saving may be roughly computed from the power developed as given in the figures in Table 4. That the copper industry considers that this saving warrants an investment in waste-heat boilers is perhaps best shown by the fact that there are to-day over 43,000 hp. of boilers set with copper-matte or smelting furnaces alone.

Copper-refining Furnaces.—As opposed to the continuous operation of a copper-smelting furnace, refining furnaces have a distinct cycle of operation, the gas weights available and gas temperatures varying widely at different periods in this cycle. While at times the temperatures from refining furnaces are as high, or perhaps higher, than those from smelting furnaces, the average over a complete cycle of operation is considerably below the average for an equal period in the smelting furnace.

The temperatures from a matte furnace average approximately 2000 to 2200 deg. In the case of the refining furnace these temperatures, over a complete cycle, will vary from about 400 deg. during charging to something over 2000 deg. while melting, and the average for such a cycle, some 30 hr., will be approximately 1400 deg. The length of the cycle and the temperature of the gas available for different periods will vary with the size and operation of the furnace. As an indication of the variation in results to be expected at different periods of the cycle, some figures on boiler capacities from a 400,000-lb. furnace may be of interest. These figures represent 30 hr. of a 33½-hr. complete cycle. The average horsepower developed during this period was approximately 320.

Period	Duration, Hr.	Average, Hp.
Charging	6	36
Melting	16	450
Poling	2	237
Between poling and tapping	1	277
Pouring	5.5	286

While the writer is not sure of the exact date of installation of the first waste-heat boiler with copper-refining furnaces, he believes that the Baltimore Smelting and Rolling Company (American Smelting and Refining Company) were the pioneers in this field. This company installed two Stirling boilers rated at 335 hp. each in 1907. These boilers, as in the case of the first installations with matte furnaces, were furnished with standard baffles. Because of interference with furnace operation, it was found necessary to incrase the baffle openings to more than twice the standard. This company has installed over 3500 hp. for additional furnaces.

Other refining companies followed the Baltimore Smelting and Rolling Company in the utilization of this class of waste heat, and the writer is familiar with over 11,000 hp. of boilers in this class of work.

As far as is known, there has been but one attempt made to utilize the theory of high gas velocity in the production of steam from copper-furnace waste gases. This was done in 1914 at the plant of the Raritan Copper Company, Perth Amboy, N. J. This company purchased three 450-hp. Babcock & Wilcox waste-heat boilers of the general design described in connection with open-hearth steel furnace practice, a design necessitating the use of an induced-draft fan for the proper operation of the primary furnace. The Raritan Copper Company has also 2600 hp. of Stirling boilers in which the principle of high gas velocity is not used, and results from the two designs are available. These results are given in Table 4.

In Test 3 the temperature of the gases leaving the furnace was 2190 deg., in the main flue, 1928, and entering the boiler, 1621 deg. This loss was due to leakage and radiation.

It will be noted from a comparison of the results of Tests 4 and 5 that the gas weight passing through the Babcock & Wilcox boiler is 42 per cent less than the weight passing through the Stirling boiler. While the entering gas temperature is some 120 deg. higher in the case of the Babcock & Wilcox boiler, the exit temperature is approximately 100 deg. lower. In other words, the gas temperature drop through the Babcock & Wilcox boiler is approximately 200 deg. greater than through the Stirling boiler for a gas weight of 20,000 lb. less.

TABLE IV—RESULTS OF TESTS OF WASTE-HEAT BOILERS WITH COPPER FURNACES

Test Number	1	2	3	4	5
Plant	Anaconda Copper Mining Co.		Inspira-tion Copper Co.	Raritan Copper Co.	
Location	Anaconda, Mont.		Miami, Ariz.	Perth Amboy, N. J.	
Furnace	Matte	Matte	Matte	Refining	Refining
Boiler	Stirling	Stirling	Stirling	Stirling	B & W
Heating surface, sq. ft.	7,500[1]	7,500[2]	14,000[3]	3,940	4,490
Gas weight, lb. per hr.	49,950[2]	98,400[2]	160,010	70,100	50,400
Gas per hr. per sq. ft. of h.s., lb.	6.66	13.13	11.38	17.79	11.23
Temperatures:					
Gas entering boiler, deg. Fahr.	2,200	2,200	1,621	1,429	1,547
Gas leaving boiler, deg. Fahr.	680[3]	890[3]	696	670	584
Drop in temp., deg. Fahr.	1,520	1,310	925	759	963
Draft at boiler damper, in.	.....	.....	0.80	1.15	2.28
Draft at boiler inlet, in.	.....	.....	0.44	0.56	0.60
Draft loss, in.	.....	.....	0.36	0.59	1.68
Horsepower developed	570[4]	970[7]	1,111	401	365
Per cent of rated capacity	76.	129	78.8	103	81.4
Approximate transfer rate (*R*)	2.3	3.6	3.4	4.9	4.0

[1]Two boilers in tandem, approximately as *A*, Fig. 5.
[2]Gas from one furnace passing through two boilers.
[3]Range, 620 to 720 deg.
[4]Front boiler, 470 h.p.; rear boiler, 100 h.p.
[5]Gas from two furnaces passing through two boilers.
[6]Range, 800 to 950 deg.
[7]Front boiler, 776 h.p.; rear boiler, 194 h.p.
[8]Two single boilers, approximately as *B*, Fig. 5. Boilers equipped with superheaters in exit flues. Horsepower includes superheat; exit temperatures are after leaving superheaters.

As was shown in the discussion of some of the results secured with open-hearth furnaces (Table 1), it would be necessary, before a direct comparison would be possible, that the gas weight per square foot of heating surface and the entering-gas temperature should be the same. On this basis, the total gas weight passing through the boiler of Test 5, for comparable results, would be approximately 80,000 lb. per hour, and with an entering-gas temperature as in Test 4, the boiler would develop 495 hp., or 11 per cent above its rated capacity. This would indicate a gain of 11 per cent in gross power developed, in favor of the more modern waste-heat boiler.

The results on such a basis are, as stated, in favor of the Babcock & Wilcox boiler, though they are not as much better as we would ordinarily expect. This is due to the fact that the fan installation is not entirely suited to the conditions which must be met. Furthermore, as a commercial proposition the fans in the present installation are motor-driven, and the power required for such drive is directly chargeable to the boiler; whereas, if a turbine drive were employed, much of the heat in the steam used for such drive could be reclaimed in feed-water heaters.

As in all waste-heat work, the power developed from these waste gases represents a very considerable saving in coal that would otherwise have to be burned under direct-fired boilers. Unlike copper matte furnaces, however, the value of this power does not represent the greatest saving through the use of waste-heat boilers. The boilers connected to copper-refining furnaces make ideal "dust catchers," and the value of the copper so reclaimed is a highly important item. The writer is not at liberty to give actual figures of savings from this source, but can state authoritatively that in one plant the value of the dust reclaimed from the boiler setting is over one and one-half times the value to the owners of the steam generated. The values of this steam may be approximated from the boiler capacities given in Table 4.

(To be concluded)

Metallurgical Clay Goods.—The Denver Fire Clay Co., Denver, Col., has issued bulletin No. 100, describing muffles, crucibles and scorifiers.

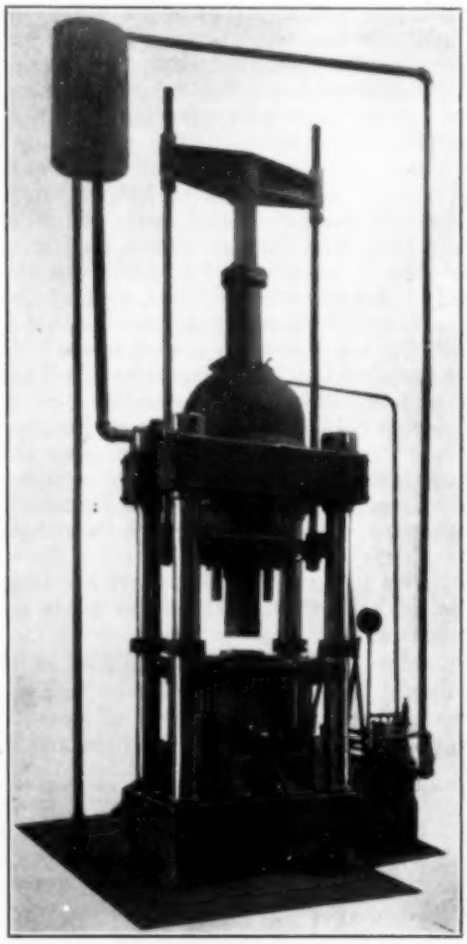
"Fuel Oil Driven Compressors" is the title of a new bulletin issued by the Chicago Pneumatic Tool Co., Chicago, Ill. The bulletin describes air compressors operating on various low grade oils.

Metallurgical Society of Missouri School of Mines.—The Metallurgical Society effected a permanent organization Nov. 14, 1916. The following officers were elected: T. P. F. Walsh, president; H. A. Horner, vice-president, and C. L. Epperson, secretary-treasurer. An executive committee, consisting of Professors Mann and Clayton, Horner, Epperson and T. P. F. Walsh, chairman, was elected to draft a constitution and make all necessary arrangements for a successful year. The society, meeting every two weeks, intends to devote its time to metallurgy, ore dressing and chemistry.

Labor Laws of Pennsylvania.—The monthly bulletin of the Department of Labor and Industry of the State of Pennsylvania for September contains a compilation of all essential portions of Pennsylvania labor laws that should be known by all employers, employees, employment agents and all those concerned with employment in any way. Mr. John Price Jackson is commissioner of the Department of Labor and Industry, his office being in Harrisburg.

Manufacturing Commercial Salt Blocks by Hydraulic Pressure

Manufacturers and producers of both evaporated and rock salt have long felt the need of efficient and profitable methods of producing commercial salt blocks of uniform size, weight and density for the prevention of waste and for the convenience of handling, shipping, etc. Both evaporated and rock salt are secured from the same source, evaporated salt being originally rock salt. Rock salt manufacturers secure their material in the same manner as coal is mined, a shaft being sunk and the salt removed in lump form. Similarly it passes over screens for obtaining different grades for various purposes. Evaporated salt is obtained by drilling a hole into the rock salt bed and casing the hole in the same manner as producers of petroleum and natural gas case their oil and gas wells. Tubes are sunk into the casing and the latter sealed at the top. Water is then pumped through the casing down



750-TON INVERTED SALT BLOCK PRESS (EJECTING SIDE).

into the salt bed for dissolving the salt, the resulting brine being forced out and evaporated.

The natural block of rock salt as it comes from the mine, is used quite extensively for stock feeding purposes because it is slow to evaporate and does not easily break up. The crude blocks are thrown into the field and left for the stock to lick at their will. However, with all of the apparent advantages of rock salt there is considerable waste in mining and handling the natural block. When removing the natural rock salt in large lumps and breaking it up in many smaller pieces and screening it, much loose salt results which

is unsuitable for commercial purposes in its natural state. There being no way to dispose of this waste loose salt, the manufacturers have left it to accumulate in piles outside of the mine or in some instances have gone to the expense of hauling it back into the mines.

When this waste salt is left in piles outside of the mine it becomes a menace to surrounding territory, because the rains wash the brine out over the land and down into the streams. This, of course, proves unsatisfactory to the farmers and owners of land surrounding the mine, because it destroys the producing value of the farm land and impairs the natural value of the fresh water streams. So much of a menace had this situation become in rock salt manufacturing centers that it attracted the attention of the Federal Government as well as individuals located in the affected territory. Thought was then turned to an efficient and profitable method of disposing of this waste and by extensive experiments it was found that solid salt blocks of uniform size, density and weight could be easily made from loose salt if placed under heavy pressure, the resulting block having no tendency to disintegrate from the effects of the weather in the open field. The only action of water is to very slowly wear away the block from the outside. When the block becomes wet and is again dried it appears to be much harder than before the moisture came in contact with it.

Evaporated salt heretofore little used for stock feeding, can be made into blocks by this method. Blocks made by the hydraulic press have proven equally satisfactory whether they are made from evaporated salt or rock salt.

The Hydraulic Press Manufacturing Co., Mount Gilead, Ohio, has developed and patented a design of hydraulic press which will produce a satisfactory salt block of uniform size and density. The accompanying photograph shows this press. It is built in two sizes, one having a pressure capacity of 1000 tons and the other 750 tons.

The salt is compressed in a mold into a compact block of uniform density approximately 8¼ in. square by 12 in. high. The salt block is removed from the mold by hydraulic pressure. The block is then removed for shipment or storage. The press is provided with a surge tank, the base of which is located higher than the main cylinder. By a simple movement of the valve lever the plunger drops to the salt in the mold and the main cylinder is filled with fluid by suction caused by the lowering of the ram as well as by the gravity of the fluid. Thus the first stroke of the pump initiates the pressure upon the salt. After the block forming operation is completed the main ram is returned by means of the auxiliary ram located at the extreme top of the press. This action returns the fluid to the surge tank. The operations of the press are controlled by hydraulic valves, the levers of which are conveniently located for the operator. The press is operated from an independent steam, belt or motor driven pump or from an accumulator system.

Some of the advantages claimed for the artificial blocks are:

That the pressed block is more shapely and does not have the rough edges and sharp shale inclusions, which are the most objectionable features of the natural block, and therefore, does not cut the mouths of the stock as the natural block does; that it has a much greater density than the natural block and will, therefore, last longer and resist the action of the weather longer in the open field; that the blocks are all uniform in size and shape; therefore, they pack to a better advantage in the car and are much more easily handled as they all weigh exactly the same; and that it is possible in manufacturing this artificial block to add sulphur or other ingredients, thus makng a medicated block.

A Machine for Testing Metal Sheets

Since none of the customary metal tests, such as the Brinell or scleroscope test, can be satisfactorily applied to metal sheet, Mr. A. M. Erichsen, a Norwegian metallurgical engineer, has designed an ingenious apparatus which permits convenient and accurate tests of all kinds of metal sheets from 0.1 to 5 mm. thickness; by using special attachments, the machine can also be successfully used for testing wires up to 6 mm. diameter, cartridge cups, metal tubing, and to determine the "spring" qualities of metal ribbons.

In the practical application of metal sheets, mostly in

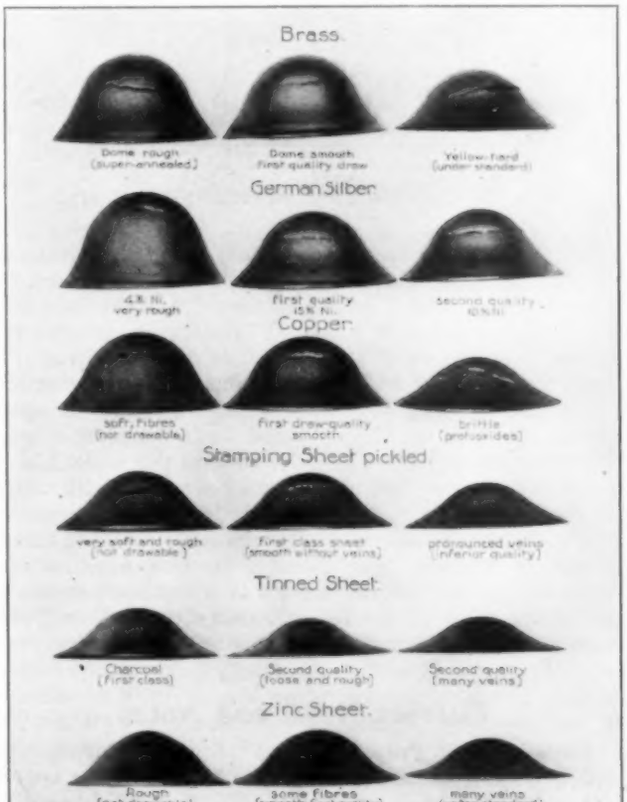


FIG. 1—RESULTS OBTAINED WITH TESTING MACHINE

drawing, stamping, or compressing operations, the ductility and tenacity of the material is of more importance than the ultimate tensile strength. The Erichsen method determines the actual "workability" of the metal sheets: a test piece is placed between a die and a holder, and a tool having a rounded end is moved gradually forward under the influence of a ram actuated by a micrometer screw and hand wheel, until the fracture occurs. The test piece is under the permanent observation of the operator through a mirror, so that the point of fracture can be ascertained with great accuracy. The "drawing value" of the material can be read off directly on the apparatus and is the basis on which the quality of the metal sheet is determined. Great tenacity combined with high tensile strength will give the best press value, which latter, however, is neither proportional to the effective modulus of elongation nor to the ultimate tensile strength. As all apparatus man-

ufactured under the Erichsen patents are made from the same precision gages and are adjusted in the same manner, the results obtained permit accurate comparisons, so that standards can be established for use in specifications of manufacturers and purchasers of metal sheets.

The illustration shows a cross-section of the machine,

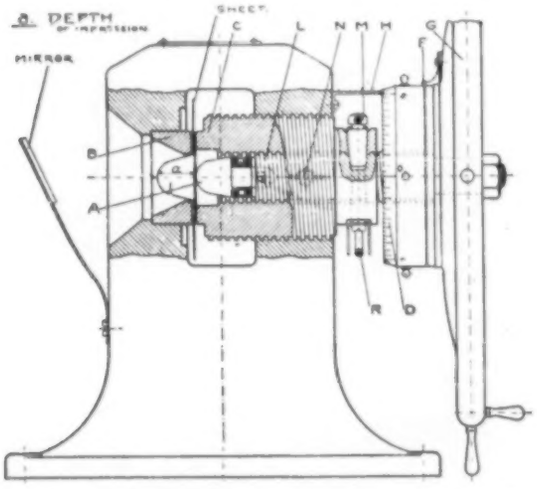


FIG. 2—CONSTRUCTION OF TESTING MACHINE

with the direct-reading scale and observation mirror. In testing a piece of sheet metal it is first placed between the die ring *B* and the holder *C* and the thickness read off the movable collar *D*. Before doing this the latter must be set at zero, which is done by turning it until the spring *F* snaps into a small hole in the collar. After determining the thickness the machine is again set at zero and the wheel turned until the piece cracks. Knowing the thickness and the amount the wheel had to be turned to crack the piece furnishes values with which to compare the piece with certain standard pieces.

Mr. Erichsen, who has introduced the machine extensively in Europe, was recently in this country and granted the sole license under his American patents to Mr. Herman A. Holz of 50 Church Street, New York, who is manufacturing the machine in this country.

Current News and Notes

Government Potash Plant for California.—In August, 1916, the Congress of the United States appropriated $175,000 for the investigation of sources of potash within the United States. This appropriation was designed to make possible the continuation on a large scale of the work inaugurated and carried on by the Bureau of Soils of the U. S. Department of Agriculture. As a result of this work, and of the operations to date of the various commercial organizations engaged in the extraction of potash from kelp on the Pacific Coast, it appeared to the officials of the Department of Agriculture that the giant kelps of the Pacific Coast represented the largest and most immediately available source of potash in the country. Accordingly the Secretary of Agriculture has authorized the construction at some point on the coast of Southern California of a plant to be designed and operated to demonstrate on a commercial scale the various processes of extracting potash and by-products from kelp. This work will be carried on by the Bureau of Soils under the personal supervision of J. W. Turrentine. The bureau proposes to proceed at once with the execution of its plans.

New Chicago Laboratory.—Dr. Rudolph R. Rosenbaum, formerly of the Central Commercial Co., Chicago, has opened an up-to-date laboratory at 53 West Jackson Boulevard, Chicago, which will be known as the Western Chemical Laboratories. While general organic analysis and research will be carried on, the organization is especially equipped to design petroleum refineries, investigate processes and industrial propositions and do analytical work on petroleum.

Dyestuffs Census Now Available.—The census of dyestuffs, compiled by Dr. Thomas H. Norton of the Bureau of Foreign and Domestic Commerce, is now available from the bureau in its revised form. The efforts of the importers to prevent the publication of the census in its original form were successful, but an effort is expected to be made by the dye-makers and consumers in this country to have Congress take some action in the matter and have the original census published, showing the quantities and values of each dye in the groups and also the key to the makers.

The Utah Chemical Company has been making regular shipments of potash and Glauber's salts from its Saltair, Utah, plant. The plant is owned by the Southern Cotton Oil Co., which uses the Glauber's salts as a fertilizer for cotton growing.

Safety in Steel Mills.—The Bureau of Mines has issued a technical paper (No. 102) dealing with "Health Conservation at Steel Mills." The author is Dr. J. A. Watkins formerly assistant surgeon of the U. S. Public Health Service and the information should prove interesting and helpful to all interested in safety work.

Water Controlling Apparatus.—The Rodney Hunt Machine Co., Orange, Mass., has issued catalog 30, describing flumes, penstocks, stand pipes, gates, valves, etc., for controlling water.

Personal

Mr. **Arthur P. Allen** has left the Calumet & Hecla Co., and is now with the Highland Mining Co., Ashcroft, British Columbia.

Mr. **Frederick K. Brunton** has resigned his position with the American Smelting & Refining Co., Garfield, Utah, and is now assistant superintendent of the Consolidated Arizona Smelting Co., Humboldt, Ariz.

Mr. **Frank R. Corwin** has resigned as assistant superintendent of the Consolidated Arizona Smelting Company, to become assistant superintendent of the International Smelting Co., at Miami, Ariz.

Mr. **C. R. Delaney** of Hanover, Pa., is chief chemist of the new plant of H. E. Young & Co., Inc., at Charlottesville, Va.

Mr. **W. E. Greenough** has resigned his position as manager of the Marsh Mining Co., Idaho, and has opened offices in the Old National Bank Building, Spokane, Wash., as an independent consulting engineer.

Mr. **Henry D. Hibbard** of Plainfield, N. J., has returned from a trip to Norway and Sweden.

Mr. **J. R. M. Klotz,** manager of the Newport Chemical Works of Carrolville, Wis., and in charge of the New York office at 32 Liberty Street, was married on Dec. 6 to Miss Margaret Sliger of Helena, Ark. Mr. Klotz is secretary of the Chemists' Club and was for many years with the Barrett Company.

Mr. **G. Komorowski,** metallurgical engineer, recently arrived in New York from France, represents the firm controlling the Girod electric furnace, and his headquarters in New York are with the American agents for the furnace, C. W. Leavitt & Co., 30 Church Street.

Mr. **C. J. Ramsburg,** vice-president of the H. Koppers Company and Pittsburgh By-Product Coking

Company, Pittsburgh, Pa., will lecture before the Franklin Institute of Philadelphia, on Feb. 1, 1917, on the "By-Product Coking Industry."

Mr. W. C. Stevens has been appointed general sales manager of the Cutler-Hammer Mfg. Co. of Milwaukee. He has been connected with the company ever since graduating from Cornell, about ten years ago. The last three years he has been in charge of the New York office. He has devoted much of his time to sales and installation work in connection with controllers for steel plants and unloading plants, including blast furnace skip hoists, ore bridges, coal bridges, coal dumpers, car conveyors and other equipment used in the steel and iron industry. He will remove from the New York office to the Milwaukee office about Jan. 1. **Mr. T. D. Montgomery** has been appointed to the position made vacant by the promotion of Mr. Stevens.

Obituary

Mr. Samuel James, manager of the Northport Smelting and Refining Company of Northport, Wash., died suddenly Saturday, Nov. 25. Mr. R. W. Marston will assume the duties of acting manager until further notice.

Book Reviews

The Journal of the Institute of Metals. Vol. XV. Edited by **G. Shaw Scott.** 390 pages. Price, 21s. net. London: The Institute of Metals.

Papers and discussion on corrosion form the predominating feature of this volume of the Institute of Metals, including the Third Report to the Corrosion Committee. There are two papers on aluminum and its alloys, one on nickel-silver (formerly known in England as German silver) and one on electric furnaces in non-ferrous metallurgy. The frontispiece is a portrait of Sir George Beilby, the new president of the Institute of Metals.

Galvanizing and Tinning. By **W. T. Flanders,** with the assistance of seven specialists. Octavo (14 x 22 cm.), 350 pages, 134 illustrations; price, $3.50. New York: David Williams Company.

The author, connected with the Malleable Iron Fittings Company, described in articles in the *Metal Worker* and *The Iron Age* the design and operation of plants for hot galvanizing and tinning, drawing upon his thirty-five years of experience as builder and manager of such plants. These articles form the nucleus of the book, to which are added three chapters on electro-galvanizing and several chapters on sherardizing. Messrs. John Calder, R. D. Foster, C. J. Kirk, A. F. Schoen, Louis Schulte, W. G. Stratton and S. Trood co-operated in these chapters, but where and to what extent is not itemized in the text. The treatment throughout is in the style and quality of the technical trade paper, being intended for practical usefulness to those operating and managing plants rather than for students of the why and wherefore of operations. It is a welcome book, containing a great deal of information not to be found elsewhere.

A System of Physical Chemistry. Vol. I, Kinetic Theory; Vol. II, Thermo-dynamics and Statistical Mechanics. By **Wm. C. McC. Lewis.** 12 by 18½ cm., 523 and 552 pages; price, $2.50 net per volume. New York and London: Longmans, Green & Co.

This is intended as a text-book for persons already knowing elementary physics and chemistry, and preferably also familiar with the broad outlines or principles of physical chemistry. It is therefore meant to be a comprehensive treatise on physical chemistry; inspection shows it to be systematic in plan and reasonably complete in detail. A strange oversight in the discussion of the additive properties of salts in solution is the omission of any reference to the additive nature of the energies of chemical combination or formation of the salts from their constituents, when measured to dilute solutions. But, aside from this, the work may be taken as a complete and clear presentation of all branches of physical chemistry.

MARKET REPORTS

The Iron and Steel Market

Shipments of Lake Superior ore down the lakes in November reached the remarkable total, for a November, of 5,715,452 tons. The vessels carried less than half the usual quantity of grain, devoting their attention more to ore. The lake movement to December 1 totals 63,648,298 tons, which, with 1,000,000 tons estimated for December and 1,500,000 tons for all-rail movement, should make the year's total a trifle more than 66,000,000 tons, against a former record of 49,947,116 tons, made in 1913. Before the navigation season opened some ore interests insisted that there would be a shortage of ore as the lake fleet would be unable to transport more than 60,000,000 tons at the outside. Various estimates were made some months ago as to the amount of ore that should be moved to ensure the furnaces operating without difficulty until the opening of navigation in 1917, the computations usually showing 62,000,000 to 64,000,000 tons. The furnaces will have no difficulty as to ore this winter, but have already experienced a shortage in coke, not sufficient to decrease the country's pig-iron production by an appreciable amount, but sufficient to produce a market for Connellsville furnace coke for spot shipment of $7 to $8 per net ton, when most of the existing contracts, to expire Dec. 31, are at from $2.15 to $2.75.

Iron and steel exports in October, returned by weight, totaled 610,096 gross tons, against 643,767 tons in September, the record tonnage for a month. Despite the decrease from September, the October exports were 26 per cent in excess of the average for the nine preceding months of the year, that average having been 484,555 tons per month. The largeness of the exports in September and October was due chiefly to there having been great increase in exports of pig iron and unfinished steel, pig iron exported in October amounting to 101,756 tons, while exports of billets, blooms, ingots, sheet bars, etc., amounted to 162,679 tons in October.

THE SCARCITY OF STEEL

References to a "scarcity of steel" first appeared in September, 1915, by which time the steel mills had reached a point of operating at capacity. If the condition then was of a scarcity the condition now is an extreme famine. Buyers for both domestic and foreign account are scouring the country for unfinished steel of all descriptions and only occasionally do they find any steel at all. Offerings are usually of tonnages much smaller than are inquired for.

There was a time, perhaps, when the scarcity of unfinished steel in the market was to be attributed to the mills being unwilling to sell unfinished steel to buyers not their regular customers because they desired to retain the steel to produce finished material for their regular customers. Such a principle no longer obtains as the mills are not making satisfactory deliveries of finished steel to their customers and a little more or less does not matter. Some of the finished steel products represent a larger profit than would be obtained by selling unfinished steel in the

market, but there are some commodities in which this is not the case. As illustrating one of the vagaries of the market, wire nails as recently advanced are $3 per keg, base, or $60 per net ton. For soft steel rods $65 to $70 would be bid, but practically none are offered. If the mill can spare rods at all it makes them in high carbon, at a slight increase in cost, and then obtains about $90.

STEEL PRICES ADVANCING

The general trend of the finished steel market is sharply upward. There can be no regularity in the movement as prices proceed by large intervals. On Dec. 4 wrought iron and steel pipe and line pipe were advanced two points or about $4 a net ton. Within a few days black, blue annealed and galvanized sheets advanced $5 a ton. Bars, plates and shapes have not advanced since the advance of Nov. 21, which was $5 a ton on plates and $4 on bars and shapes. An advance of $5 a ton is predicted to occur before the end of the month.

Advances in finished steel prices are to be attributed, in general, to the increasing value of steel as steel, and thus there is generally a coherence between price advances in the different commodities, but there are various exceptions, plates being the most striking. The plate mill and slabbing mill capacity of the country is altogether insufficient for this abnormal demand, and plates even for the most forward delivery are about $10 a ton higher than the related commodities, bars and structural shapes, but while plates at 3.50c. are high there have been bids of 5c. for ship plates for delivery during the first half of 1917.

As suggestive of the vagaries in the market it may be noted that for several weeks, until early in December, railroad spikes were 2.65c., Pittsburgh, and 2.75c., Chicago. They had gotten into a rut and meanwhile steel bars had advanced to 2.90c., Pittsburgh, although the cost of conversion used to be figured at about $9 a net ton and is presumably higher now. Suddenly, spikes started to advance and in a few days were 3.40c., Pittsburgh, and 3.50c., Chicago, an advance of $15 a net ton.

UNFINISHED STEEL

Soft steel billets, Bessemer or open-hearth, are quoted at $55 to $57 as representing approximately the market, though rarely is the market actually shown by transactions. For export they would readily bring $55, Pittsburgh or Youngstown, but bids as high as $60 are not yet made. Soft steel rods are about $70, with high carbon at about $90, and forging billets are in the neighborhood of $75. It is believed that nearly all the shell steel billets to be bought for 1917 are already under cover, the total business in shell steel for the year being in the neighborhood of 3,000,000 or 4,000,000 tons. Shell steel billet discards readily bring $35.

PIG IRON

Pig iron continues to advance at the average rate of about 20 cents per business day, the rate mentioned in last report, but the rate seems to have increased a trifle. Bessemer iron is at least $35, Valley furnaces, while basic has been in the neighborhood of $30. The advance is probably in part psychological, sellers finding it easy to secure advanced prices while buyers are moved to purchase by seeing the market advance so rapidly. There is talk of an actual scarcity of pig iron, but until the prompt market is definitely higher than the forward market judgment may be suspended. That there is fear of a serious shortage of pig iron is beyond question. The production cannot be materially increased, while it may decrease through shortage of coke, while the consumptive capacity is increasing by constant additions to the open-hearth steel making capacity of the country.

Non-Ferrous Metal Market

Dec. 8.—Copper continues in its strong position chiefly owing to the ability of the producers to sell far into the future, making supplies scarce. Tin is less active in spite of small arrivals, lead is very strong, while spelter is somewhat weaker. The rise in silver is expected to bring about a record production.

Copper.—Copper has advanced further and electrolytic is now quoted at 35.25 bid to 35.75 asked for prompt delivery. Lake is quoted at 34.50 to 35.00 for prompt delivery. Buying eased off a little during the last few days in November, but since then inquiries have been resumed with a rush. Exports during November amounted to only 21,433 tons, but this is explained by the scarcity of freight room on outgoing steamships. Our exports this year will be higher than in 1915, but will not be as high as in 1914 and 1913, when 360,229 and 382,810 tons respectively were exported. Many large domestic consumers have covered their requirements for nearly all of 1917, and it is this buying far into the future which places the producers in such a strong position. Copper may go higher, but with our enormous production there does not seem to be any good reason for it, although domestic demand at present is enormous. Casting copper is very scarce, with sellers asking 33.00 to 33.50 cents for prompt delivery.

Tin.—Straits tin has declined from 45.50 on Nov. 27 to 43.80 cents on Dec. 7. Buying has been very dull in spite of the fact that deliveries in November were far below normal and there is no change in England's attitude in issuing permits. November arrivals totaled 2230 tons, to which must be added our home production at Perth Amboy, N. J., of about 400 tons. There is not so much Chinese tin coming in as formerly, and the attitude of buyers in holding off is hard to understand.

Lead.—The trust price of lead was advanced to 7.50 cents New York on Dec. 5. It is predicted that lead will go to 8 cents, and independents are already asking 7.50 to 8.00 cents. Domestic demand outside of war supply needs is the chief factor influencing the market at the present time.

Spelter.—Spelter has weakened considerably and eased off from 13.30 asked on Dec. 1 to 12.17½ asked on Dec. 7. The chief factor in the decline has been the eagerness of dealers to sell while the demand continues about the same.

Other Metals.—Antimony is quiet, with Chinese and Japanese quoted at 14.37½. *Aluminium* is unchanged in the open market and brings 63.00 to 65.00 cents. Silver is up to 75⅝, and, needless to say, production will be pushed to the limit. Platinum continues almost prohibitive at $105.00 per oz. Magnesium is unchanged at $3.50 per lb., electrolytic nickel is 50.00 cents, quicksilver $80.00 per flask and tungsten ore $18.00 per unit.

General Chemicals

WHOLESALE PRICES IN NEW YORK MARKET DECEMBER 7.

Acetone, drums	lb.	$0.22½	$0.23
Acid, Acetic, 28 per cent	100 lb.	3.50	3.65
Acetic, 56 per cent	100 lb.	7.00	7.15
Acetic, glacial, 99½ per cent, carboys	lb.	.25	.30
Boric, crystals	lb.	.12¾	.13¼
Citric, crystals	lb.	.65	.67
Hydrochloric, commercial, 18 deg	100 lb.	1.75	2.00
Hydrochloric, 20 deg	100 lb.	2.00	2.25
Hydrochloric, C. P., conc., 22 deg	100 lb.	2.25	2.50
Hydrofluoric, 30 per cent, in barrels	lb.	.05	.05½
Nitric, 36 deg	lb.	.06¼	.06½
Nitric, 42 deg	lb.	.07	.07¼
Oxalic, crystals	lb.	.51	.55

Phosphoric, 85 per cent	lb.	.29½ —	.30
Picric	lb.	.90 —	1.00
Pyrogallic, resublimed	lb.	3.25 —	3.45
Sulphuric, 60 deg.	100 lb.	1.50 —	1.75
Sulphuric, 66 deg.	100 lb.	1.75 —	2.00
Sulphuric, oleum (Fuming)	100 lb.	1.75 —	2.00
Tannic, U. S. P., bulk	lb.	.90 —	1.06
Tartaric, crystals	lb.	.66 —	.70
Alcohol, grain, 188 proof	gal.	2.72 —	2.73
Wood, 95 per cent	gal.	.95 —	.97
Denatured, 180 proof	gal.	.65 —	.67
Alum, ammonia, lump	lb.	.04 —	.04¼
Chrome	lb.	.25 —	.26
Potash, lump	lb.	.05¼ —	.06½
Aluminium sulphate, technical	lb.	.03½ —	.04½
Aluminium sulphate, iron free	lb.	.05 —	.05½
Ammonia aqua, 26 deg., carboys	lb.	.06 —	.06¼
Ammonium carbonate	lb.	.10 —	.10½
Ammonium sulphate, domestic	lb.	.. —	.04¼
Amyl acetate	gal.	4.50 —	4.80
Antimony salt, 75 per cent	lb.	.. —	..
Antimony sale, 65 per cent	lb.	.. —	..
Antimony salt, 47 per cent	lb.	.. —	..
Argois	lb.	.08 —	.09
Arsenic, white	lb.	.06½ —	.07
Barium chloride	ton	110.00 —	115.00
Barium nitrate	lb.	.13½ —	.15
Barium peroxide	lb.	.. —	.36
Bleaching powder, 35 per cent	lb.	.04¾ —	.07½
Borax, crystals, sacks	lb.	.07¾ —	.08
Brimstone, crude	ton	28.50 —	29.00
Bromine, technical	lb.	1.40 —	1.45
Calcium acetate, crude	100 lb.	3.50 —	3.55
Calcium carbide	ton	73.00 —	75.00
Calcium chloride, 70-75 p. c. fused, lump	ton	23.00 —	26.00
Calcium chloride, granulated	ton	.. —	..
Calcium peroxide	lb.	1.50 —	..
Calcium sulphate	lb.	.10 —	.20
Carbon bisulphide	lb.	.06 —	.07
Carbon tetrachloride, drums	lb.	.16½ —	.17
Caustic potash	lb.	.78 —	.90
Caustic soda, 76 per cent	lb.	.05 —	.05¼
Chlorine, liquid	lb.	.15 —	.25
Copperas	100 lb.	1.25 —	1.50
Copper carbonate	lb.	.45 —	..
Copper chloride (cupric)	lb.	.55 —	.60
Copper cyanide	lb.	.. —	.65
Copper sulphate, carloads	lb.	.14 —	..
Cream of tartar, crystals	lb.	.39½ —	.41
Epsom salt, bags, tech	100 lb.	1.75 —	2.00
Formaldehyde, 40 per cent	lb.	.10½ —	.12
Glauber's salt	100 lb.	.50 —	.75
Glycerine, bulk	lb.	.52½ —	.53
Hydrogen peroxide, 1-lb. bottles	gross	18.00 —	..
Iodine, resublimed	lb.	4.25 —	4.35
Iron oxide	lb.	.13 —	.15
Iron sulphide	lb.	.04 —	.05
Lead acetate, white crystals	lb.	.13 —	.13½
Lead arsenate, pulped	lb.	.08 —	.09
Lead nitrate	lb.	.14 —	.15
Lead oxide, litharge, American	lb.	.. —	.07¼
Magnesium carbonate	lb.	.21 —	.23
Nickel salt, single	lb.	.11 —	.11½
Nickel sale, double	lb.	.08 —	.08½
Phosphorus pentachloride	..	.. —	..
Phosphorus, red	lb.	.. —	1.00
Phosphorus, yellow	lb.	.. —	.80
Potassium bichromate	lb.	.40 —	.42
Potassium bromide, granular		1.35 —	1.36
Potassium carbonate, calcined, 80-85 p. c.	lb.	.40 —	.45
Potassium chlorate, crystals	lb.	.65 —	.66
Potassium cyanide, 98-99 per cent	lb.	nominal	
Potassium iodide	lb.	.. —	3.50
Potassium muriate, 80-85 p.c., basis 80 p.c.	ton	450.00 —	460.00
Potassium nitrate	lb.	.32 —	.33
Potassium permanganate	lb.	3.00 —	3.50
Potassium prussiate, red	lb.	2.50 —	2.75
Potassium prussiate, yellow	lb.	.92½ —	.95
Potassium sulphate, 90-95 p.c., basis 80 p.c.	ton	275.00 —	300.00
Rochelle salts	lb.	.34 —	..
Sal ammoniac, gray	lb.	.10 —	.12
Sal ammoniac, lump	lb.	.17 —	.18
Sal soda	100 lb.	1.10 —	1.25
Salt cake	ton	13.00 —	14.00
Silver cyanide, price depends on silver mkt.	oz.	.70 —	..
Silver nitrate	oz.	.46½ —	.48½
Soda ash, 58 per cent	lb.	.03¼ —	.03¾
Sodium acetate	lb.	.14 —	..
Sodium benzoate	lb.	8.25 —	8.75
Sodium bicarbonate, domestic, f.o.b. works	lb.	.02 —	.03½
Sodium bicarbonate, English	lb.	.03½ —	.04
Sodium bichromate	lb.	.22 —	.23
Sodium bisulphate	..	.. —	..
Sodium chlorate	lb.	.28 —	.30
Sodium cyanide	lb.	nominal	
Sodium fluoride, commercial	..	.. —	..
Sodium hyposulphite	lb.	.01¾ —	.02¼
Sodium nitrate, tech	100 lb.	3.10 —	3.20
Sodium nitrite	lb.	.18 —	.20
Sodium peroxide	..	.. —	..
Sodium phosphate, U. S. P.	lb.	.05 —	.06
Sodium prussiate	lb.	.55 —	.57½
Sodium silicate, liquid	100 lb.	.85 —	1.00
Sodium sulphide, 30 per cent, crystals	lb.	.. —	.03½
Strontium nitrate	lb.	.28 —	.30
Sulphur, crude, f.o.b. New York	ton	.. —	29.50
Sulphur, flowers, sublimed	100 lb.	2.50 —	2.70
Sulphur, roll	100 lb.	1.95 —	2.25
Tin bichloride, 50 deg.	lb.	.15 —	.15½
Tin oxide	lb.	.50 —	.52
Zinc carbonate	lb.	.25 —	.27
Zinc chloride	lb.	.10¼ —	.11½
Zinc cyanide	lb.	.45 —	..
Zinc oxide	lb.	.12 —	.13
Zinc sulphate	lb.	.07½ —	.08

Coal Tar Crudes

Benzol, pure white	gal.	$0.55 —	$0.60
Toluol, pure	gal.	2.25 —	3.00
Xylol, pure	gal.	1.00 —	1.25
Solvent naphtha, light		.28 —	.32½
Solvent naphtha, heavy		.. —	..
Creosote		.. —	..
Dip oil	gal.	.30 —	.35
Pitch, various grades	ton	14.00 —	16.00

Intermediates, Etc.

Acetanilid	lb.	$0.50 —	$0.55
Alpha naphthol		.. —	..
Aniline oil	lb.	.23 —	.30
Aniline salts	lb.	.36 —	.55
Anthracene, 80 per cent	lb.	.10 —	.12
Benzaldehyde	lb.	5.00 —	7.00
Benzidine	lb.	1.90 —	2.25
Benzoic acid	lb.	10.00 —	12.00
Beta naphthol, sublimed	lb.	1.20 —	1.25
Chlor benzol		.. —	.31
Cresol, U. S. P.	gal.	1.35 —	1.40
Dimethylaniline	lb.	1.50 —	1.75
Diphenylamine	lb.	.90 —	1.10
Metaphenylinediamine	lb.	1.05 —	1.75
Naphthalene	lb.	.10 —	.10½
Naphthionic acid, refined	lb	2 25 —	..
Ortho toluidine	lb.	1.45 —	1.65
Paranitraniline	lb.	1.50 —	1.75
Para toluidine	lb.	1.70 —	1.90
Phenol, drums	lb.	.52½ —	.55
Resorcin, technical		9.00 —	..
Salicylic acid, bulk	lb.	1.20 —	1.35
Sulphanilic acid	lb.	.45 —	.60

Petroleum Oils

CRUDE (AT THE WELLS)

Pennsylvania	bbl.	.. —	$2.75
Corning, Ohio	bbl.	.. —	2.10
Somerset, Ky.	bbl.	.. —	2.20
Wooster, Ohio	bbl.	.. —	1.70
Indiana	bbl.	.. —	1.33
Illinois	bbl.	.. —	1.52
Oklahoma and Kansas	bbl.	.. —	1.00
Caddo, La., light	bbl.	.. —	1.00
Corsicanna, Tex., light	bbl.	.. —	1.00
California	bbl.	.73 —	.82

LUBRICANTS

Black, reduced, .29 gravity, 25-30 cold test	gal.	$0.13½ —	$0.14
Cylinder, light		.21 —	.26
Cylinder, dark		.18 —	.19
Extra cold test		.26 —	.31
Paraffine, high viscosity		.29½ —	.30
Paraffine, .903 spec. gr.		.21½ —	.22
Paraffine, .865 sp. gr.		.18½ —	.19

Flotation Oils

(F.O.B. WORKS IN BARRELS)

Pine oil, steam distilled, G. N. S. No. 5	gal.	.60
Pine oil, destructively distilled, G. N. S. No. 6	gal.	.48
Pine-tar oil, G. N. S. No. 8	gal.	.21
Pine-tar oil, double refined, G. N. S. No. 9	gal.	.29
Pine oil, light, Georgia Pine No. 182	gal.	.37
Pine oil, heavy, Georgia Pine No. 205	gal.	.26
Pine tar, thin, G. N. S. No. 14	gal.	.16
Turpentine, crude, G. N. S. No. 11	gal.	.35
Hardwood oil, G. N. S. No. 17	gal.	.16
Creosote, coal tar, neutral, G. N. S. No. 20	gal.	.12
Creosote, coal tar, acid, G. N. S. No. 22	gal.	.21½

Vegetable and Other Oils

China wood oil	gal.	$0.11 —	$0.12¾
Cottonseed oil, crude, f.o.b. mills	gal.	.86 —	.87
Linseed oil, raw	gal.	.96 —	.99
Rosin, 280 lb.	bbl.	6.75 —	6.80
Rosin oil, first run	gal.	.38 —	.39
Turpentine, spirits	gal.	.52 —	.52½

Miscellaneous Materials

Barytes, floated, white	ton	$25.00 —	$35.00
Chalk, light, precipitated, English	lb.	.03¼ —	.05½
Feldspar	ton	8.00 —	15.00
Fuller's earth, powdered	100 lb.	.80 —	1.05
Plaster of Paris	bbl.	2.00 —	2.25
Red lead, dry	lb.	.. —	.07¾
Soapstone	ton	8.00 —	12.00
Talc, American, white	lb.	.02 —	.04
White lead, dry	lb.	.. —	.07

Refractories, Etc.

(F.O.B. WORKS)

Chrome brick	net ton	$110.00—$120.00
Chrome cement, Grecian	net ton	60.00— 70.00
Clay brick, 1st quality fireclay	per 1000	35.00— 40.00
Magnesite, Grecian, dead burned	net ton	85.00— 90.00
Magnesia brick, Grecian, 9x4½x2½	net ton	135.00— 145.00
Silica brick	per 1000	40.00— 45.00

Ferroalloys

Ferrochromium		Nominal
Ferromanganese, domestic, delivered	ton	$155.00—$165.00
Ferromolybdenum	lb.	4.00— ..
Ferrosilicon, 50 p.c., carloads, del. Pittsburgh	ton	100.00— ..
Ferrotungsten, 75-85 p.c., f.o.b. Pittsburgh	lb.	2.50— ..
Ferrovanadium, f.o.b. works	lb.	2.75— 3.00

INDUSTRIAL

Financial and Construction News

Financial

Air Reduction Company, Jersey City, N. J., is incorporated for $150,000 to manufacture and deal in oxygen, nitrogen and liquid air. The incorporators are C. H. Jarvis, Philip L. Nieser, Jersey City, and John R. Turner, Basking Ridge, N. J.

Akron Metal Products Company, Akron, Ohio, incorporated for $100,000. The incorporators are Herbert E. Lawrence, M. B. Glore, W. C. Tappenden, C. W. Dennett and Thomas Brennan.

Alaska Seaboard Copper Company, Seattle, Wash., incorporated with $1,000,000 capital by Wm. H. Byington, Jr., J. Henry Denning, W. W. Sweet.

Alcohol Chemical Co., Wilmington, Del., is incorporated for $10,000 to buy, sell and extract and deal in alum, sulphate and chloride. The incorporators are Cornelius A. Cole, Robert A. Van Voorhis and Arthur R. Oakley.

Alliance Chemical Company, Boston, Mass., is incorporated for $50,000. The incorporators are Alan A. Claflin, Joseph N. Paradis and Francis G. Hayes.

Alpha Chemical Works, Inc., Bound Brook, N. J., is incorporated with a capital of $100,000 to manufacture and deal in chemicals and dyes. The incorporators are Rovert von Cleff, George W. Study, New York, and Lester C. Burdett, Palisade, N. J.

American Aniline Products Company, Inc., was recently incorporated with $500,000 capital in New York State.

Amolin Chemical Company, Lodi, N. J., incorporated with $25,000 to manufacture and deal in chemicals and fabrics for dress shields, by John Behrens, Hasbrouck Heights, and Harry Lemmermann, Bronxville, N. Y.

Atlas Color Works, Inc., Brooklyn, N. Y., incorporated with $25,000 to manufacture dyestuffs by F. R. Ficken, C. Zobel, 270 Ninth Street; P. Zobel, 524 Ninth Street, Brooklyn.

Barnet Burgess Chemical Co. is incorporated with a capital of $100,000 to buy and sell and extract and deal in alum, aluminium, silicon and metals of all kinds. The incorporators are Cornelius A. Cole, Hackensack, N. J.; Robert A. Van Voorhis, Jersey City, and Arthur R. Oakley, Pearl River, N. Y.

William Becker's Aniline & Chemical Works, Brooklyn, has increased its capitalization from $2,000,000 to $5,000,000.

Belleville Chemical Company, Belleville, N. J., incorporated with $50,000 to manufacture chemicals.

Brewster Oil Company, Portland, Ore., incorporated with $500,000 capital to conduct a general business in the production, manufacture and selling of oils, natural gases and other mineral substances. Incorporators, C. F. Tenant, Portland; Elton H. Thompson, Portland, and Frank B. Schofield, Portland.

Brooks Bros. Dyeing Company, Inc., is incorporated with a capital of $80,000 to carry on the business of dyeing, tinting and coloring. The incorporators are H. A. H. and A. Brooks, Rochelle Park, N. J.

Carbo-Nitrates Company, Wilmington, Del., incorporated with $5,000,000 to mine coal, lignite, feldspar, etc. Incorporators: J. H. Reid, Sherman, Vt.; George P. Christy, Pittsburgh, Pa.; H. A. Porter, Crafton, Pa., and J. M. Bergman, Avalon, Pa.

Carso Paper Company, Boston and Dansville, N. Y.; capital, $100,000. Incorporators: J. Butler Studley, Newton; Philena E. Gamage, Waltham; Robert Weston, Cambridge, and Elizabeth D. Peabody, Medford.

Cascade Paper Company, Tacoma, Wash., incorporated with $425,000 by Frank S. Baker, D. den Bleyker and J. T. S. Lyle.

Chemical Carbon Refining Company, Chicago, Ill., has increased its capital stock from $25,000 to $40,000.

The Chemical Refractories Company, Youngstown, Ohio, incorporated with $10,000 capital by J. B. Kennedy and others.

Commonwealth Mining Company, Spokane, Wash., is incorporated with a capital of $1,300,000. The incorporators are M. A. Phelps, J. F. Sexton and C. H. Williams.

Connecticut Steel Corporation, Wilmington, Del., is incorporated with a capital of $5,000,000 to manufacture metals and articles made from metals. The incorporators are Herbert E. Latter, Norman P. Coffin and Clement M. Enger.

Consumers Sulphur Company, Inc., Wilmington, Del., is incorporated with a capital of $1,500,000 to manufacture pyrites, sulphur, gypsum stone, ores, metals and minerals. The representative is H. M. Keith, 17 Battery Place, New York City.

Continental Products Company, Cleveland, Ohio, incorporated with $35,000 to manufacture paints by M. M. Roche, Maurice M. Murphy, Mary B. Grossman, Alvin L. Bochmer and Ival Donahue.

Cosmic Metal, Philadelphia, Pa., is incorporated for $500,000 to manufacture bearing metals by amalgamation. The incorporators are F. R. Hansell, George H. B. Martin and S. C. Seymour.

Cosmopolitan Oil & Paint Mfg. Company, Cicero, N. Y., incorporated to manufacture and deal in paints and oils. Capital, $60,000.

Dowling Iron & Steel Company, Boston, Mass., is incorporated for $20,000. The incorporators are Martin A. Dowling, George Blaney, Benjamin F. deCosta and William J. E. Sander.

Eagle Rock Oil Company, Wilmington, Del., is incorporated with a capital of $500,000 to prospect for oil, petroleum, gas, coal and other minerals. The incorporators are W. F. O'Keefe, George G. Steigler and E. E. Wright, Wilmington.

Elmstrom Leather Company, Boston, Mass., is incorporated with a capital of $25,000, 250 shares at $100 each. Directors: Robert M. Elmstrom, 27 Lincoln Street, Boston, president and treasurer; E. L. Elmstrom and H. E. Johanson.

Esmeralda Mines Corporation, New York, incorporated with $3,000,000 capital to mine copper, gold, silver, etc. Incorporators: Samuel B. Howard, L. H. Gunther and Arthur W. Britton, all of New York.

Eureka Chemical Company, Wilmington, Del., incorporated with $100,000 capital to manufacture and deal in chemicals.

H. E. Friedrich Chemical Mfg. Company, Westfield, N. J., incorporated with $10,000 to manufacture and deal in chemicals and drugs by Spencer D. Embree, Harry S. Embree, of Westfield, and Richard C. Rice of New Brunswick, N. J.

Federal Dyestuff & Chemical Company, Kingsport, Tenn., offered Dec. 8 to 11, through White & Co., Hanover Bank Building, New York, a limited amount of common stock at $50 per share. The company owns 200 acres of land at Kingsport and has twenty-nine buildings devoted to the manufacture of dyestuffs and chemicals, the present production being 50,000 tons per year. The company has strong financial backing and is capitalized at several millions.

General Synthetic Company, Newark, N. J., incorporated with $100,000 capital by Rupert G. Gates, East Orange; Joseph E. Cohen, Michael Silver, Newark. Will manufacture and deal in all kinds of chemicals.

George Strong Harral Company, Inc., Brooklyn, N. Y., incorporated with $75,000 capital to manufacture soaps, disinfectants, chemicals, by G. S. Harral, Brooklyn; A. Miller and L. F. Skiver of 60 Wall Street, New York.

Hawkeye Leather Company, Des Moines, Iowa, is incorporated with a capital of $10,000. Louis Banagas is president and T. F. Mansfield is secretary.

Iridescent Dyestuff & Color Company, Inc., Brooklyn, N. Y., is incorporated for $25,000 to manufacture dyestuffs, colors, chemicals and drugs. The incorporators are H. Audley, H. R. Brown and C. W. Tiffin, 650 East 228th Street.

Kansas Oil Investment Company, New York, N. Y., is incorporated with a capital of $25,000 to acquire lands containing oil and gas and to develop the same. The incorporators are Allen P. Hallett, Arthur M. McKnight and Ira T. McKnight, all of New York.

Keystone Dyestuff & Chemical Company, Newark, N. J., incorporated with $300,000 capital to manufacture and deal in dyes, acids, chemicals and colors. Incorporators: Edward J. Fuchs, Henry C. Beecher, Newark; Charles J. Justice, Woodhaven, L. I.

M. & M. Oil Burner Company, Spokane, Wash., incorporated with $100,000 capital by E. C. Moulds, A. B. Moulds, L. R. Stithen, James S. Lane and Alexander Moses.

Marine Oil Company, San Francisco, Cal., is incorporated with a capital stock of $200,000, 200,000 shares at $1 each, to produce and deal in oil and gas. The subscribers are W. C. Tupper, V. Shaw, W. J. Dinsmore, L. Barneson and M. Syme.

Mars Paper Corporation, New York, chartered in Delaware with $100,000 capital to manufacture paper and paper products, by Arthur W. Britton, Samuel B. Howard, L. H. Gunther, all of New York.

Massillon Foundry & Machine Company, Massillon, Ohio, capital increased from $200,000 to $300,000.

The North American Antimony Smelting Company, Ltd., incorporated in Canada with $2,000,000, presumably by American interests who recently secured an option on the antimony mines at Lake George, in the St. Stephen consular district.

Oil Fork Development Company, Louisville, Ky., incorporated with capital of $80,000, divided into shares of $1 each, to develop oil lands in Eastern Kentucky. The incorporators are C. F. Blakey, Irvin Marcus and Z. Starr.

Pan-American Laboratories, Inc., Wilmington, Del., incorporated to manufacture chemicals with $50,000 capital.

Passaic Leather Company, Inc., New York City, N. Y., is incorporated with a capital of $100,000 to manufacture leather, lumber belting, etc. The incorporators are J. F. O'Neill, Boonton, N. J., and L. H. Healy, 2 Virginia Place.

Petrole Refining Products Company incorporated with $1,500,000 to manufacture petrol and own oil wells, gas wells, etc. Incorporators: Valentine Robinson, Charles V. Barker, Brooklyn; Armand Lablach, New York.

The Potash Company of Utah, Marysville, Utah, incorporated with $1,500,000 to develop the alunite deposits in Piute County. The company, it is said, owns more than 600 claims adjoining those of the Mineral Products Company, one of the first potash manufacturers in the United States. The principal place of business of the Potash Company will be at Marysville. The officers named in the articles of incorporation are Don R. Johnson, president; F. B. McCarthy, secretary-treasurer, and C. S. Hammond, director. Other incorporators are Walter W. Byrne, Swift & Co., and Frank W. Taylor of Philadelphia, head of one of the largest chemical houses in the United States.

The Roe and Stugo Chemical Company, New York City, has been incorporated with a capital of $10,000. T. Weiranch is a director.

The Royal Oil & Gas Company, Zanesville, Ohio, has been incorporated with a capital of $35,000.

The Sandusky Forge Company, Sandusky, Ohio, has been incorporated with a capital of $300,000. J. Barrows, Jamestown, N. Y., is president, M. E. Crow, Elkhart, Ind., is vice-president, and W. H. Collier, Painesville, Ohio, secretary-treasurer.

The Sanol Chemical Company, St. Louis, has been incorporated with a capital of $50,000. Incorporators are J. H. Wedemeyer, W. R. Gilbert.

Seaboard Oil Corporation, Lakewood, N. J., incorporated with $500,000 to acquire mineral rights and produce oil, gas and mineral substances. Incorporators: John W. Magnall, Joseph R. Norris, Butler, N. J., and Edwin W. Warfield, New York.

Silver Bell Mining Company, Spokane, Wash., is incorporated with a capital of $1,500,000. The incorporators are E. H. Belden, R. F. Blackwell, James M. Kirkpatrick, James C. Broad and H. N. Metzger.

Silver Mountain Mining Company, Spokane, Wash., incorporated with $1,500,000 capital by W. E. Seelye, Boyd Hamilton and John Hunt Shepard.

Silver Side Mining Company, Salt Lake City, Utah, is incorporated with a capital of $50,000 to operate mines in Alpine district, Utah county. The incorporators are W. W. Hammell E. T. Culmer, H. P. Huey, William Holmes and E. H. Roberts.

The Sixty-Six Oil Company, Wichita Falls, has been incorporated in Texas with a capital of $16,000. The incorporators are T. B. Noble, F. N. Lawton, P. C. Straus.

Smidth-Lewis Foundry Company, Elizabeth, N. J., is incorporated with a capital of $10,000 as iron founders and metal workers. The incorporators are Stephen G. Williams, Kenneth McEwen, New York, and John J. Griffin, East Orange, N. J.

Southeastern Alaska Copper Corporation, Seattle, Wash., incorporated with $3,000,000 capital by H. E. Willis, R. W. Sweet, J. Henry Denning.

The Sovereign Gas Company, Huntington, W. Va., has been incorporated with a capital of $30,000. Incorporators are G. W. Keller, J. I. Miller, G. D. Miller, L. S. Wiles, W. H. Kitley.

Square Deal Paint Company, Benton Harbor, Mich., has been incorporated with a capital of $2,000,000.

State Chemical Mfg. Company, Cleveland, Ohio, incorporated with $10,000 by A. E. Bernsteen.

The Steelman Realty Gas & Oil Company, Millville, N. J., has been incorporated in New Jersey, with a capital of $300,000, to drill for natural gas and oil on lands. The incorporators are L. Steelman, M. A. Steelman, Le Roy I. Steelman, Millville.

Storm Water-Proofing Corporation, New York, incorporated with $65,000 capital to manufacture paints, cements and other water-proofing materials. Incorporators: C. R. Allison, W. I. Glover, C. C. Pinney, 115 Broadway, New York.

Sunshine Chemical Company, St. Louis, Mo., incorporated with $10,000 capital to manufacture and sell non-inflammable polishes, paints and varnish. Incorporators: H. C. Henly, H. D. Isch and F. W. Johnson.

The Suffern Company, Inc., Brooklyn, N. Y., has been incorporated with a capital of $2,500, to deal in chemicals, minerals, and metals. The incorporators are C. R. McPherson, H. B. Deyo, C. Damast, 537 Bedford Avenue, Brooklyn.

The Syn Galenic Chemical Company, Sandusky, Ohio, incorporated with $50,000 by Harry J. Fisher and others.

Taylor Lake Oil Company, Houston, Tex., is incorporated with a capital stock of $30,000. The incorporators are E. Alkemeyer, L. S. Vickery and Macks Miller.

Trinity Mining Company, Tacoma, Wash., incorporated with $100,000 capital by A. L. Beebe and J. W. Mitchell.

The Trinity Products Company, Dallas, Tex., incorporated with $75,000 to manufacture bleached fiber and other fiber products.

United Dye Works, Seattle, Wash., has been incorporated with a capital of $8,000. Incorporators: D. Taylor, B. Penman, H. Gilbert, G. Barg, M. Greenberg.

The United Dyewood Corporation has been authorized to issue $5,000,000 in 7 per cent cumulative preferred stock and $4,500,000 of it is being offered by Blair & Co., of New York.

The United Dyewood Corporation is the holder of substantially all of the capital stock of the American Dyewood Company, British Dyewood Company, Limited; West Indies Chemical Works, Limited; and Cie Francaise des Extraits Tinctoriaux et Tannants. The company carries on an extensive business both in American and Europe. The average earnings of the subsidiary companies for the three years ended Dec. 31, 1915, were $1,772,224.

The United States Petroleum Company, San Francisco, Cal., has been incorporated with a capital of $510,000, to operate and develop oil and gas lands. The incorporators are H. R. Peacock, E. L. Peacock, G. A. White, R. L. McWilliams, E. Schwab, H. H. Phleger, R. C. Foerster.

The Victor Fertilizer Company, Camden, N. J., has been incorporated with a capital of $100,000. Incorporators are H. J. Koehler, J. F. Sutton, K. L. Fraiser.

Vulture Wonder Mines Company, New York City, incorporated with capital of $2,000,000 to do a general mining business of all kinds. The incorporators are George A. Manning, Campbell, N. Y.; Leo. J. Bonding, New York, and Robert B. Cross, Westfield, N. J.

Walker Bros. Consolidated Copper Company, Salt Lake City, Utah, incorporated with $1,000,000 capital to work 400 acres of copper bearing lands in Plumas County, Cal. J. R. Walker and George Bemis are interested.

Ware Coated Paper Company, Ware, R. I., incorporated with a capital of $150,000, 1500 shares at $100 each. The directors are Henry K. Hyde, president; Wm. W. McLaurin, Brookfield, treasurer, and John McLaurin.

Western Chemical Company, Cleveland, Ohio, incorporated with $25,000 capital by George H. Fleming, Daniel Kellackey, P. S. Summers, P. J. Maloney and E. R. Hayes.

Watervliet Paper Company, Watervliet, Mich., has increased its capital from $400,000 to $600,000.

The Wilkes-Barre Structural Steel Company, Wilkes-Barre, Pa., has been incorporated with a capital of $40,000.

The Wisconsin Process Company, of Milwaukee, incorporated with $10,000 capital to manufacture and sell chemicals. Incorporators: A. U. Stettem, L. E. Fichaux and E. W. Passmore.

J. Early Wood, Inc., New York City, has been incorporated with a capital of $10,000 to deal in chemicals. Lorenzo I. Jones of Brooklyn is a director.

Wyoming Central Oil Co., Wilmington, Del., has been incorporated with a capital of $1,000,000 to drill and produce oil. Incorporators are M. L. Rogers, L. A. Irwin, H. W. Davis.

The Zobel Color Works, Brooklyn, N. Y., have been incorporated with a capital of $200,000 to manufacture colors, dyestuffs, etc. The incorporators are E. W. Stratmann, W. P. Hamilton, Jr., and G. R. Foody.

Construction and Operation

Alabama

WOODWARD.—The Otto Coking Company, Inc., New York, has received a contract for the erection of 60 Wilputte By-Product Coke Ovens at the plant of the Woodward Iron Company, Woodward, Ala. The new ovens will have a capacity of 13 net tons of coal, and will operate on an 18-hr. coking time. Work is being rushed on the construction, and the new battery is scheduled to start operation about July, 1917.

Arizona

TURKEY.—A cyanide plant for treating gold ore blocked out at the Golden Belt mine is planned by Lon D. Hall and W. W. Eliott. The mine is commonly known as the old Zika property.

California

LOS ANGELES.—The report has been confirmed that the Union Oil Company will erect a $2,500,000 oil refinery at Los Angeles Harbor. The company wants the Harbor Commission to build a wharf and dredge the approach, the company advancing the money for the work. The company intends to erect a plant similar to that of the Standard Oil at El Segundo.

LOS ANGELES.—The Warman Steel Casting Company has made public the details of its new factory buildings to be erected at Huntington Park. The works will consist of a main foundry, a pattern shop, a storage room and an office building. Three electric furnaces and a special oxy-acetylene welding plant will be installed. Peoples & Chaney, 912 Haas Building, are preparing the plans.

MANTECA.—The Spreckels Sugar Company will erect a $2,000,000 sugar refinery in or near Manteca. Nothing definite as to the time of starting construction is known. Manteca is in the South San Joaquin Irrigation District.

MONTEBELLO.—The California Oil, Metal & Chemical Manufacturing Company, which has been operating for some time in Los Angeles, has removed to South Montebello. The company makes liquid soaps, floor sweep, etc.

NEVADA CITY.—The Twenty-one Mine at Alleghany will erect a ten-stamp mill to replace the roller mill plant now in use. J. H. Hunt of Nevada City is supervising the erection.

SANTA BARBARA.—The California Chemical Company will erect a kelp treating plant at Summerland, near Santa Barbara. The plant will cost between $30,000 and $50,000. Presumably this is a potash proposition.

SANTA CLARA.—The Western Grain & Sugar Products Company is erecting an 80 by 200-ft. addition to its potash plant, which department of the company employs about 60 men.

Colorado

DENVER.—The Jackson Compressor Company has been organized with $250,000 capital, and will construct a manufacturing plant at Alameda Avenue and Cherokee Street, to manufacture air compressors. Mr. H. O. Jackson, who is at the head of the company, has been working for a long time on a small rotary compressor and has evolved a compressor which it is believed will find much use in metallurgical work, as well as general use. The company will employ about 600 men.

DENVER.—The Ferro Alloy Company plans the erection of a $50,000 tungsten reduction plant at Utah Junction. The company will manufacture ferro-tungsten, and will be the first company to do this west of Chicago. Operations will start Feb. 1, 1917. Guilford S. Wood of Denver is president, Robert M. Keeney, well known electrometallurgical engineer, is general manager and superintendent, and David C. Dodge is chief chemist.

Connecticut

HARTFORD.—A general increase in wages has been put into effect at the Lydall & Foulds Paper Company, the William Folds Paper Company and the Colonial Board Company. This makes the third increase in the last twelve months.

STAMFORD.—Baer Brothers, paint manufacturers, have purchased the Lincrusta works for $70,000. The Lincrusta Company retains its machinery and will vacate early in 1917, and the purchasing company will occupy the entire factory and install a considerable amount of new machinery as well as some of the machinery from the company's present plant at 437 West Thirty-seventh Street, New York City.

Delaware

WILMINGTON.—The Enterprise Foundry Company recently chartered in Delaware, with $50,000 capital will take over the foundry business of William M. Meyers. Mr. Meyers will remain as manager of the plant. He is also vice-president of the new company.

Florida

JACKSONVILLE.—Plans being prepared to rebuild Florida Cotton Seed Oil Mills, Denson and Lemon Streets, recently destroyed by fire; loss, $80,000.

Georgia

WAYCROSS, GA.—Promoters have been investigating wood supplies in this section with a view to establishing a large paper mill here early in 1917.

Illinois

CHICAGO.—Contract awarded by James Kirk & Company, 106 East Austin Avenue, to George A. Fuller Company, 140 South Dearborn Street, for erecting eight-story soap factory on river corner West North Avenue and Fleetwood Street; cost, about $800,000.

EAST PEORIA.—The Oelkers, Pfaindler, Lester Foundry Company, a new concern, will establish a foundry here for making metal castings. The main office will be in East Peoria.

Indiana

ALEXANDRIA.—The Penn-American plate glass factory, which five years ago was the largest manufacturing plant of its kind in the world, has been sold by S. J. Mack, secretary of the company, to William Faye, of St. Louis, Mo., general manager of the General Insulating & Manufacturing Company. The cash consideration was $85,000. The company also bought fifty acres of land adjoining and announcement was made that machinery for the manufacture of mineral wool products will be made here.

Kentucky

LEXINGTON.—A company, headed by State Senator Charles H. Knight, of Louisville, has taken an option on a site on the Louisville & Nashville Railroad, on which a plant for the manufacture of fertilizer is to be erected during the next three months.

LEXINGTON.—The Melick Refining Company will start work on its new $2,500,000 oil refinery next March. David L. Melick is local representative.

LOUISVILLE.—The Standard Oil Company, of Kentucky, will build a $1,000,000 refining plant in Louisville, which it is understood will turn out a variety of oils, including illuminating, fuel and oils for road purpose.

Louisiana

LEESVILLE.—The plant of the Independent Stores Company at Insco, two miles north of here, was partially destroyed by fire on Nov. 28. Besides the still house, fifty barrels of rosin and 200 barrels of crude were destroyed.

NEW ORELANS.—The Z. L. Cullinan interests of Houston, Tex., known as the Federal Petroleum Company, has purchased the rights to 400,000 acres of oil lands in Southwest Louisiana and Texas. A large refinery may be erected on the gulf coast to make lubricants, the oils being especially suited for this purpose.

SHREVEPORT.—A conference was held here on Nov. 24 of representatives of the Texas Iron & Steel Company, and the United States Reduction Company, of New York, in regard to the erection of a plant to smelt the iron ores of Cass and Marion counties in East Texas, using natural gas

from the North Louisiana fields as fuel. The process to be used is the invention of Charles S. Bradley, well known engineer, of New York City. While it has long been recognized that these ores were of great value, no coal lands are located in the vicinity and this stood in the way of their development.

Maryland

BALTIMORE.—A large artificial silk mill is being erected by J. L. & M. Maerkens at Curtis Bay. They formerly operated a plant in Belgium.

BALTIMORE.—The Aluminum Ore Company, a subsidiary of the Aluminum Company of America, plans the erection of a bauxite refining plant at Sollers Point, near Sparrows Point, Md., on a large tract of land recently purchased. The plant will cost about $1,000,000 and will be completed early in 1918. It will be built by the engineering department of the Aluminum Company of America, with C. B. Fox, superintendent of a similar plant of the company at East St. Louis, Ill., in consultation.

ELKTON.—The Jessup & Moore Paper Company, which operates the Radnor Pulp Works here, announced that it would erect a bleach mill at a cost of $500,000.

Massachusetts

HOLYOKE.—The Keith Paper Company will erect a larger addition to its plant at Turner's Falls, which will double its capacity. The Ranger Construction Company has the contract.

Michigan

MANISTIQUE.—This town is expected to experience quite a boom, as it has been announced that a 50-ton paper mill would be built. L. C. Harmon of Minneapolis, president of the Upper Peninsula Development Bureau and vice-president of the Consolidated Lumber Company, has closed a deal with Twin City financiers making the plant possible. A $300,000 pulp mill is at present being erected by Francis W. Little and other Twin City financiers on the Manistique River, where they have obtained water rights.

Minnesota

LITTLE FALLS.—The Hennepin Paper Company is making several improvements at its plant, including two new boilers in the boiler house, with Jones self feeders, and a combination cutter. Eight new water wheels will also be installed.

Montana

BOULDER.—The East Side Butter Company is erecting a $60,000 cyanide mill.

LIBBY.—J. H. Ehlers of Spokane and M. E. Wilson, a banker of Minneapolis, announced that a $10,000,000 pulp mill is contemplated for Libby by large pulp makers.

Nebraska

OMAHA.—Morris & Company has erected a new fertilizer plant in South Omaha, costing $40,000. The equipment is being moved in.

New Jersey

MILLVILLE.—Plans are reported to have been prepared by the Whitall-Tatum Company for a large glass factory at Millville, to produce glassware for domestic and foreign trade.

New York

NEWBURGH.—The Stilson Corporation is erecting an oil refinery here. A hydrogenation system, patented by William H. Stilson, will be used. The Stilson Company is a subsidiary of the Southern Oil & Transport Company, a $20,000,000 corporation formed some time ago to merge a number of Mexican oil companies. Mr. Stilson will remove his laboratory from Jersey City to Newburgh.

Ohio

DAYTON.—The Lindenhall Company has been incorporated with $10,000 capital to manufacture aniline dyes, as the result of experiments made by the C. A. Kurz Chemical Company. The incorporators are Walter L. Kurz, T. L. Howard, M. E. Bayless, and others.

Oklahoma

BRISTOW.—The Continental Refining Company, which recently increased its capital stock from $75,000 to $1,000,000 will enlarge its refinery so as to refine oil and make all the by-products. Work is now in progress and by spring it is expected to have a capacity of 3500 barrels a day.

Oregon

PORTLAND.—The Northwest Steel Company will build a $1,000,000 rolling mill. The Monarch mills have been sold and their operation will be extended.

Pennsylvania

ALLENTOWN. — The old Allentown Foundry Company has been purchased by D. George Dery, for a silk plant, and the Bradley Pulverizer Company, manufacturers of pulverizing machinery for reducing refractory materials to powder.

BRISTOL.—Plans are prepared for erecting dye plant on canal opposite cotton bleachery plant. Daniel F. Walters, 53 Wister Street, Philadelphia, owner.

PHILIPSBURG.—The Philipsburg Clay Products Company will manufacture building brick, and later on tile, low-grade fire bricks, etc. They have secured 150 acres of coal and clay lands here and will construct a plant in the spring, the winters being of such a character as to prohibit construction work.

PITTSBURGH.—The Burdett Oxygen Company will complete the erection of their Pittsburgh, Pa., plant, at Fortieth Street and Allegheny Valley Railroad, on Dec. 1, 1916, and will be in a position to furnish oxygen to users in the Pittsburgh territory. The Pittsburgh plant is the eleventh plant erected by the Burdett Company in the various industrial centers of the country.

POTTSTOWN.—The Eastern Iron & Steel Company has shut down its No. 2 furnace because of the shortage of coke. A new furnace will be erected, to be completed by April 1, 1917.

Rhode Island

PAWTUCKET.—The Eureka Dyeing & Bleaching Company is erecting a three-story concrete and wood addition to its plant, which will treble its capacity.

Tennessee

CHATTANOOGA.—The chamber of commerce and the city board of commissioners have had under consideration the building of a new wharf, and it was announced recently that no action would be taken until the matter of locating the government nitrate plant had been definitely decided. The committee states that if the nitrate plant is located at Muscle shoals that a much larger wharf will be needed as the freight shipments here will be much larger.

Texas

EL PASO.—Reported W. and C. C. Bush will erect $50,000 ice plant.

PORT ARTHUR.—The Texas Company is erecting thirty-three extra stills to take care of increasing business. The cost is said to be about $150,000.

Utah

SALT LAKE CITY.—If suitable clay can be found in Utah the Lookout Mountain Paint Company of Chattanooga, Tenn., will establish a factory here within the next year.

SALT LAKE CITY.—The Potash Company of Utah, capitalized at $1,500,000, will develop the alumite and potash deposits of southern Utah. The claims adjoin those of the Mineral Products Corporation at Marysville. Shafts will have to be sunk to get the alumite deposits. Some of those interested are Dr. B. H. Payne of San Francisco, Walter W. Byrne of Salt Lake City, Senator Penrose of Pennsylvania, and Harry W. Clarke, eastern railroad director.

SALT LAKE CITY.—The Salt Lake Chemical Company, owned by the Diamond Match Company, has completed a six-mile pipe line and will shortly operate its plant at Grants, Tooele County, built to obtain potash from the waters of Great Salt Lake. J. M. Sullivan is in charge of the plant.

Virginia

CHARLOTTESVILLE.—The plant of H. E. Young & Company, Inc., will probably start operations April 1, 1917, producing extracts for dyeing, tanning and color making. The machinery is all installed and is expected to turn out 30,000 lb. annually. H. E. Young of Hanover, Pa., is president; J. D. Young of Charlottesville is superintendent and general manager, and C. R. Delaney of Hanover, Pa., in chief chemist.

PETERSBURG.—The du Pont Powder Company is understood to be making a number of experiments at its Hopewell plant at which gun cotton is made, with a view to turning it into a permanent industry after the war. Such products as lead pencils, automobiles and dyestuffs are talked of.

RICHMOND.—The Dixie Paper & Pulp Company, recently organized, has taken over the property at the foot of Seventh Street, known as Brown's Island, and is remodeling and enlarging the building. Richmond is gradually forging to the front as a paper-manufacturing center. It is the home of the Standard Paper Company, the largest concern in the blotting paper field. The Manchester Board & Paper Company and the Albemarle Paper Manufacturing Company, both with large plants. The Richmond Paper Manufacturing Company several years ago sold its brands and is now engaged in the wholesale paper business.

Washington

TACOMA.—The Alaska-Endicott Mining & Milling Company, 402 Tacoma Building, Tacoma, Wash., incorporated about a year ago, will develop mining property on William Henry Bay, about 40 miles north of Juneau. A small plant will be installed now with a 30-hp. engine, compressor outfit, etc., the ore being shipped to Tacoma for reduction. They plan the installation of a 100-ton oil flotation plant next year.

TACOMA.—The Cascade Paper Company of Tacoma, a new company with $425,000 capital, expects to erect a paper-making plant in Tacoma. Plans have not yet been fully decided upon. The officers are D. den Bleyker, J. T. S. Lyle and F. S. Baker.

West Virginia

CHARLESTON.—The Cabin Creek Refining Company has plans for erecting a $1,000,000 gasoline refining plant. The company is a subsidiary of the Ohio Cities Gas Company.

CHARLESTON.—The new plant of the Roessler & Hasslacher Chemical Company being erected in the Kanawha Valley is expected to be completed by April 1, 1917. About 150 men will be employed at the start. The new buildings cover six or seven acres, about a mile below St. Albans. The company owns 225 acres of land and has plenty of room for future extensions. The representatives of the company now in St. Albans are R. N. Sargent, manager of one of the company's plants at Perth Amboy, N. J.; J. C. Downs, and N. H. Guth. The plant will have a siding on the Chesapeake & Ohio Railroad.

WHEELING. — The Whitaker-Glessner Company will construct a $200,000 warehouse on a site recently purchased. The work will be done by the Foundation Company and the Riverside Bridge Company. A permit has also been granted to the La Belle Iron Works for the erection of a gas producing plant to house five gas tanks. The plant is now under construction and will cost $18,000.

WHEELING.—Work on the new plant of the United Zinc & Smelter Company is progressing rapidly. The foundations for the furnaces and most of the buildings have been completed.

Wisconsin

MILWAUKEE.—The Herman Zohrlaut Leather Company will be operated by the Pfister & Vogel Leather Company. New additions will be made to the Zohrlaut plant, to cost $15,000.

MILWAUKEE.—The Progressive Metal & Refining Company will build a two-story addition to its plant at Barclay and Washington Streets.

Wyoming

WORLAND.—A large beet-sugar factory is contemplated for the Big Horn Basin section by a new company called the Wyoming Sugar Company, capitalized at $1,000,000. The principal stockholders are said to be Joseph R. Eccles and Charles E. Kaiser of Ogden; Olaf Using, a New York banker; J. L. Williams of San Francisco, George S. Crosby of Billings, Mont., and Herman B. Gates, state treasurer of Wyoming. The Great Western Sugar Company is now constructing a plant at Lovell in the same district.

Canada

FREDERICTON, N. B.—Fraser's, Ltd., St. Johns, N. B., contemplate the erection of a pulp mill to be operated by a separate company with $4,000,000 capital.

The Nashwaak Pulp & Paper Company, which bought the mills and lands of the Partington Pulp & Paper Company, will cut 20,000,000 feet of timber this winter.

QUATSINO SOUND. — The Colonial Pulp & Paper Mills, Ltd., will erect a sulphite mill here with a capacity of 120 tons a day. The first unit will have a capacity of 60 tons. It is expected that the plant will be completed within a year.

Korea

Shipment of the material for the new battery of 50 Wilputte By-Products Coke Ovens to be erected by Mitsubishi Goshi Kaisha at Kenjiho, Korea, is rapidly being completed by the contractors, Otto Coking Company, Inc., New York. The new ovens will furnish the coke for the blast furnace plant now being erected for the Mitsubishi Company at Kenjiho.

"It may be safely asserted that Electrochemistry owes its astonishing modern growth, first, to the development of the dynamo, and second to the production of Acheson-Graphite Electrodes."

This statement was made by a gentleman who holds a very eminent position in the field of Electrochemistry.

Our question is:

Will you let Acheson Electrodes help you in your work?

THEY are made without bond in many sizes in the form of rods, tubes and plates, being solid pieces of graphite composed of about 99.5 per cent. graphitic carbon. They can be machined, threaded and cut with greatest ease. The possibility of continually maintaining a longer length of electrode without undue waste, when using graphite, by joining on new pieces as it is burned away, offers perhaps the simplest means of avoiding undue heating of the metal connector from conducted heat, while it also prevents stub-end loss.

Write us about your Electrode needs. Ask us to send you any of the following booklets of interest to you:

Booklet 449-I Electrolytic Work (in English)
Booklet 452-I Electrothermic Work (in English)
Booklet 450-I Electrolytic Work (in French)
Booklet 453-I Electrothermic Work (in French)
Booklet 451-I Electrolytic Work (in German)
Booklet 454-I Electrothermic Work (in German)

Acheson Graphite Company

Niagara Falls, N. Y., U. S. A.

E. G. Acheson, Ltd., 5, Chancery Lane, London, W. C., England

PUBLISHER'S PAGE

"Our advertising campaign in your paper is giving very excellent results"

THE WILLIAMS PATENT CRUSHER AND PULVERIZER CO.
MANUFACTURERS OF CRUSHING AND GRINDING MACHINERY
OLD COLONY BUILDING CHICAGO June 27, 1916.

The Metallurgical & Chemical Engineering,
239 West 39th St., New York City.

Gentlemen:-

We take pleasure in stating that our advertising campaign that has been running in your paper for some time is giving very excellent results. We have a number of inquiries from large industrial plants, several from foreign countries, and we are satisfied that the investment is going to bring handsome returns.

The writer had in mind carrying an advertisement in your paper for several years, but never gave the matter serious thought until recently when I noticed in the reading columns of your paper some very excellent articles on a varied line of material in which we were directly interested with a view of marketing certain crushers, and I was quite surprised to find that your journal, in its editorial columns, covered such a variety of materials.

I also wish to add that the sale of our machinery in chemical plants has increased perhaps 100% in the last six months. We consider your journal a very excellent medium to reach some of the very best industries in this country.

Yours very truly,
THE WILLIAMS PAT. CRUSHER & PULVERIZER CO.
J. M. Williams
General Sales Agent.

JUNE 1, 1916 METALLURGICAL AND CHEMICAL ENGINEERING 29

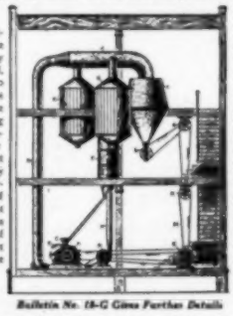
ABSOLUTE UNIFORMITY
LEAST HORSE POWER
LOWEST MAINTENANCE COST
GREATEST CAPACITY

A grinding and separating system in order to be a success must possess at least the four characteristics enumerated above; the product delivered must be of absolute uniformity in order to maintain its value and command its price; horse power should be the lowest possible consistent with efficient work; the cost of operation and maintenance should be the least possible, for economy; and the capacity should be the greatest possible per horse power consumed.

THE WILLIAMS-HICKMAN SYSTEM OF FINE GRINDING AND SEPARATING

embodies all these characteristics, it delivers a product, no matter of what degree of fineness, whether 100, 200, 300, or 400 mesh, of absolute uniformity with the least horse power, little if any expense for maintenance and greatest possible capacity per horse power and besides is simple, automatic, adjustable, dustless and both labor and power saving.

As stated before, these outfits will grind and separate any dry, soft material to any degree of fineness desired, whether 100, 200, 300, 400 mesh, or any intermediate degree of fineness, and are built in capacities ranging from 100 lbs. per hour upwards to 8 tons per hour. Another very important feature is the adjustability of these outfits; the operator may vary the degree of fineness in his product at will, by the simple means of a lever on the outside of the separator; or he can set it to produce continually the same degree of fineness.



In order to demonstrate to you that these outfits will really do what we claim for them, we have installed in our testing plant at St. Louis a full size outfit, and are prepared to grind and separate any material in quantities of 100 lbs free of charge. If you are in doubt as to the ability of this outfit to do your work, send us 100 lbs. of your material transportation charges prepaid, tell us what you want to do, that is, how fine you want to grind it (sending, if possible, a small sample of the finished product), and upon receipt of same we will be glad to test it for you and submit our full and comprehensive report. There is no charge for this test aside of your prepaying the transportation charges.

Bulletin No. 18-G Gives Further Details

In addition to the above-described outfit we manufacture Crushers, Grinders and Pulverizers for many other materials, as shown in the table below and if interested in machinery for any of these materials kindly specify catalog desired by number which will assure your receiving the proper literature.

NO. 12	NO. 12-A	NO. 12-B	NO. 12-C	NO. 12-D	NO. 12-E	NO. 12-F	SPECIAL
Limestone, Coke, Coal, Clay, Slag, Phosphate Rock, Fire Clay, Gypsum	Shale, Coal, Coke, Clay, Fire Clay	Crushing, Drying, Grinding and Pulverizing Coal and all Materials	Old Coke, Cement Rock, Soft Coke, Clay, Gypsum, Etc.	Small Coal and all Materials	Coal Crushers for Coke Ovens and all Materials	Grinding, Drying, Pulverizing Coal and all Materials	Slag Crusher and Grinder, Phosphate Rock and all Chemicals

The Williams Patent Crusher & Pulverizer Company

Works: St. Louis, Mo.

General Sales Dept. Old Colony Bldg., Chicago, Ill.

SALES OFFICES AT
New York City Philadelphia Pittsburg Richmond, Va. Cleveland Detroit San Francisco

CHLORINE AND ITS PRODUCTS

As engineers and contractors, we offer exceptional service on the construction of complete plants for producing chlorine gas, liquid chlorine, caustic soda, bleach, etc.

Cell room of 8-ton bleach plant under construction

OUR SCOPE

Industrial Plants, Power Houses, Chemical Plants, Intakes, Tunnels, Dams, Bridges, Sea Walls, all classes of heavy foundation work.

THE FOUNDATION COMPANY

NEW YORK CHICAGO PITTSBURG SAN FRANCISCO

Coal Tar Pitch

COAL TAR PITCH is more resistant than other bituminous materials to chemical reactions such as oxidation.

It is more resistant than other bituminous materials to the solvent action of most acids.

It is absolutely unaffected by prolonged contact with water, in marked contrast with other bituminous materials.

It is very high in dielectric strength.

It can be obtained of any desired consistency from a sticky semi-solid material of 100°F melting point to a dry, hard substance of 300°F melting point.

Write to the Research Department, The Barrett Company, 17 Battery Place, New York City, for specific information about the physical or chemical properties of Coal Tar Pitch, with relation to your particular problem.

The Barrett Company

New York, Chicago, Philadelphia, Boston, St. Louis, Cleveland, Cincinnati, Pittsburgh, Detroit, Birmingham, Kansas City, Minneapolis, Nashville, Salt Lake City, Seattle, Peoria.

THE PATERSON MFG. CO., LIMITED: Montreal, Toronto, Winnipeg, Vancouver, St. John, N. B., Halifax, N. S., Sydney, N. S.

TRADE B MARK

American Dyes for American Dyers

DYES

American Orange 2 A
Metanil Yellow
Azo Orange
Chrysoidine
Acid Red
Sulphur Brown
Sulphur Black
Nigrosine

EXTRACTS

Logwood
Hematine
Quercitron
Aurantine
Fustic
Cutch

CHEMICALS

Soda Ash
Caustic Soda
Caustic Potash
Chloride of Lime
Chlorate of Soda
Chlorate of Potash
Bichromate of Soda
Bichromate of Potash
Prussiate of Soda
Prussiate of Potash
Barium Nitrate
Ammonium Nitrate
Carbonate of Potash

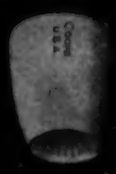
INTERMEDIATES

Aniline Oil, Pure
Aniline Oil, U.S.P.
Aniline Salt
Sulphanilic Acid
Dimethylaniline
Beta Naphthol
Paranitraniline
Phenol, U.S.P.
Nitrobenzol
Nitrotoluol
Toluidene
Picric Acid
Diethylaniline
Diphenylamine
Nitroso Dimethylaniline

Let us supply full details

MARDEN, ORTH & HASTINGS CO., INC.

NEW YORK, 61 Broadway
BOSTON, 225 Purchase Street
CHICAGO, 130 North Fifth Avenue
SAN FRANCISCO, 316 Clay Street



Get acquainted with

Coors Chemical and Scientific Porcelain

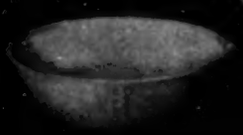
U. S. A.

Its superiority is attested to by the fact that practically all the Laboratory Supply Dealers in the United States and Canada are stocking it.

Laboratory sizes carried everywhere. Industrial designs will be made to meet unusual requirements.

The Herold China & Pottery Co.

Golden, Colorado



The Roessler & Hasslacher Chemical Co.

Manufacturing and Importing Chemists

Chemicals for All Industries

100 William Street, New York

BRANCHES: Boston, Cleveland, Philadelphia, Chicago, Kansas City, St. Louis, Cincinnati, San Francisco, New Orleans

WORKS: Perth Amboy, N. J. Niagara Falls, N. Y.

THE ROESSLER & HASSLACHER CHEMICAL COMPANY NEW YORK CHEMISTS TRADE MARK

Gold Medal Award

Panama-Pacific International Exposition, San Francisco, 1915

"SODIUM CYANIDE"

used in solution for the extraction of precious metals

"CYANEGG" for fumigation in horticulture

"CYANOGRAN" (granular), for heat treatment and case hardening

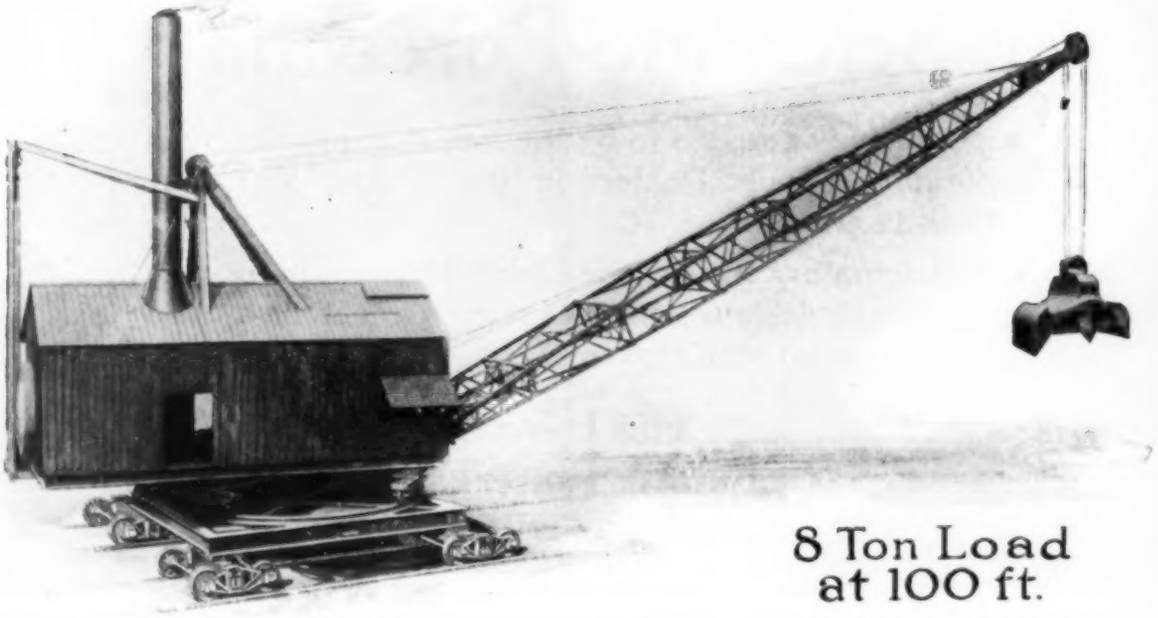
Other Gold Medal Awards

Chicago, 1894 Omaha, 1898 Buffalo, 1901

Grand Prize—St. Louis, 1904

Metal Cyanides and Trisalyts for Electro Plating

Do You Need a Large Crane



8 Ton Load at 100 ft.

This BROWNHOIST Bucket Crane

will handle at 100 ft. radius

5 yds. of COAL
3 " " SAND
3 " " GRAVEL
3 " " STONE
3 " " ORE

THERE are just two of these cranes left. And 90 days shipment can be made on either or both.

These are wide gauge machines of very large capacity and great reach. Eight tons can be handled at 100 ft. radius, which means that the crane will work a grab bucket that weighs 8 tons or less when loaded and 60 to 70 trips can be made in an hour.

This is a good opportunity to get a large capacity crane with a delivery that is considered very good at these times.

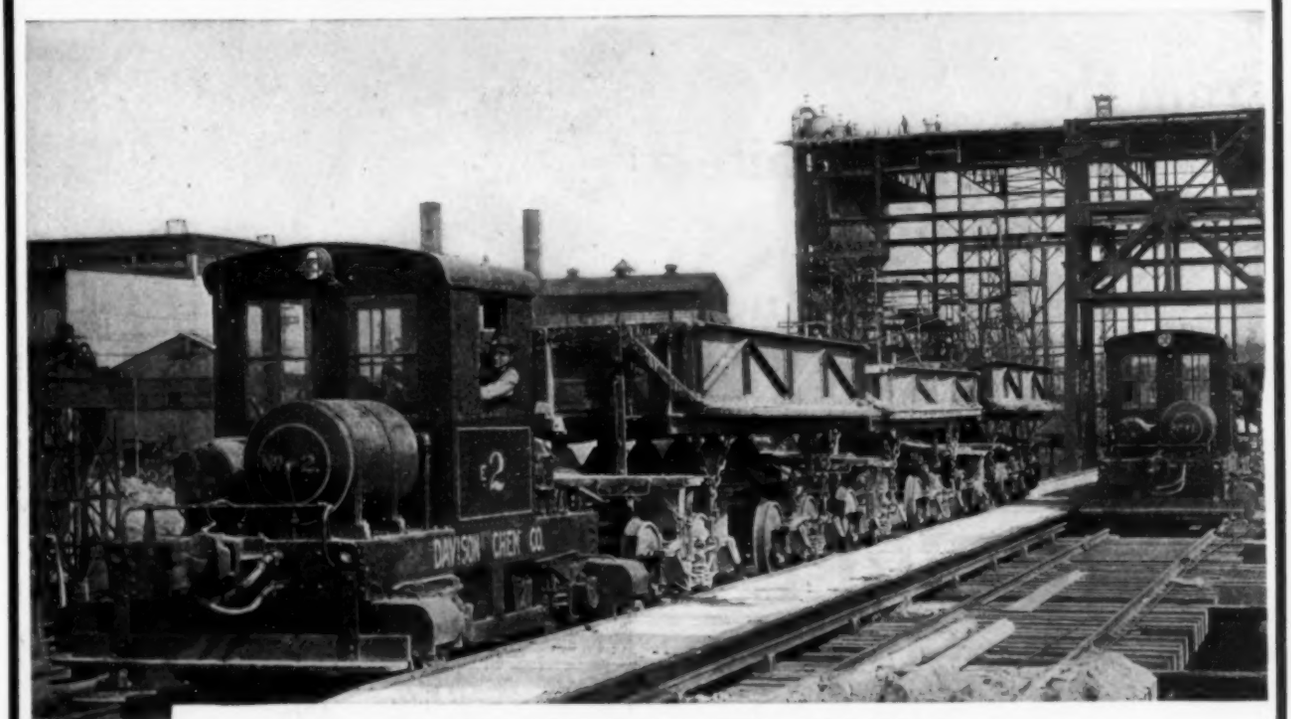
IMPORTANT. We have just sold one of these machines, but there are two left. These can be completed and shipped in 90 days.

Write or wire us for price and any other details.

The Brown Hoisting Machinery Co.
Cleveland, Ohio, U. S. A.

Engineers and Manufacturers of Cranes and Hoists

Branch Offices in New York, Pittsburgh, Chicago, San Francisco, Montreal and Portland, Ore. (Colby Eng'r Co.)



G-E Locomotives at Davison Chemical Co.

Use Electric Locomotives Between Ship and Storage

The Davison Chemical Company at Baltimore, Maryland, is unloading phosphate by means of electric locomotives manufactured by the General Electric Company.

These industrial locomotives are complete with every modern device. Air brakes assure quick, smooth braking and make possible great records in unloading. Headlights for night work and protected third rails, to leave a clear space overhead, are but two of the many convenient features of this equipment.

When waiting for a ship no current is supplied to the third rail and the cab doors are locked; thus no power bill is accumulating and men are released for other work.

Possibly there are places in your establishment where G-E industrial locomotives can be used to advantage. All types are available from yard locomotives for handling freight trains to small storage battery locomotives for indoors. The latter are small enough to be taken on freight elevators and used on more than one floor.

Your inquiry is solicited.

General Electric Company

Atlanta, Ga.
Baltimore, Md.
Birmingham, Ala.
Boston, Mass.
Buffalo, N. Y.
Butte, Mont.
Charleston, W. Va
Charlotte, N. C.
Chattanooga, Tenn
Chicago, Ill.
Cincinnati, Ohio
Cleveland, Ohio
Columbus, Ohio
Dayton, Ohio
Denver, Colo.
Des Moines, Iowa
Duluth, Minn.
Elmira, N. Y.
Erie, Pa.
Fort Wayne, Ind.
Hartford, Conn.
Indianapolis, Ind.

General Office: Schenectady, N. Y.

ADDRESS NEAREST OFFICE

Jacksonville, Fla.
Joplin, Mo.
Kansas City, Mo.
Knoxville, Tenn.
Los Angeles, Cal.
Louisville, Ky.
Memphis, Tenn.
Milwaukee, Wis.
Minneapolis, Minn.
Nashville, Tenn.
New Haven, Conn.
New Orleans, La.
New York, N. Y.
Niagara Falls, N. Y.
Omaha, Neb.
Philadelphia, Pa.
Pittsburgh, Pa.
Portland, Ore.
Providence, R. I.
Richmond, Va.
Rochester, N. Y.
St. Louis, Mo.
Salt Lake City, Utah
San Francisco, Cal.
Schenectady, N. Y.
Seattle, Wash.
Spokane, Wash.
Springfield, Mass.
Syracuse, N. Y.
Toledo, Ohio
Washington, D. C.
Youngstown, Ohio

For MICHIGAN BUSINESS refer to General Electric Company of Michigan, Detroit. For TEXAS, OKLAHOMA and ARIZONA BUSINESS refer to Southwest General Electric Company (formerly Hobson Electric Co.), Dallas, El Paso, Houston and Oklahoma City.
For CANADIAN BUSINESS refer to Canadian General Electric Company, Ltd., Toronto, Ont. GENERAL FOREIGN SALES OFFICES, Schenectady, N. Y.; 30 Church St., New York City; 83 Cannon St., London, E. C., England.

6618

From the Vein of Graphite To the Finished Product

The various steps of the building of

BARTLEY CRUCIBLES

are based on four important points:

First — The careful grading of the raw material by repeated analysis.

Second—Painstaking mixture and preparation.

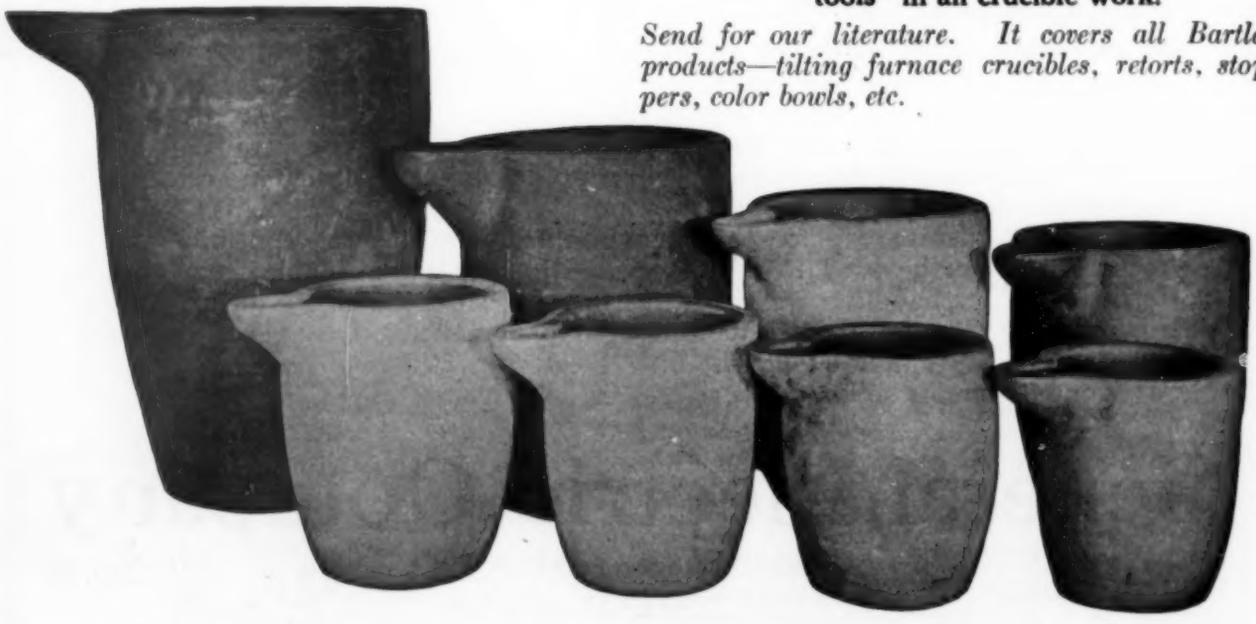
Third — Perfect molds and machinery for the formation of the crucibles under just the right pressure to make the walls homogeneous.

Fourth—Exact and sufficient burning.

Vein of Graphite in Solid Rock
Island of Ceylon

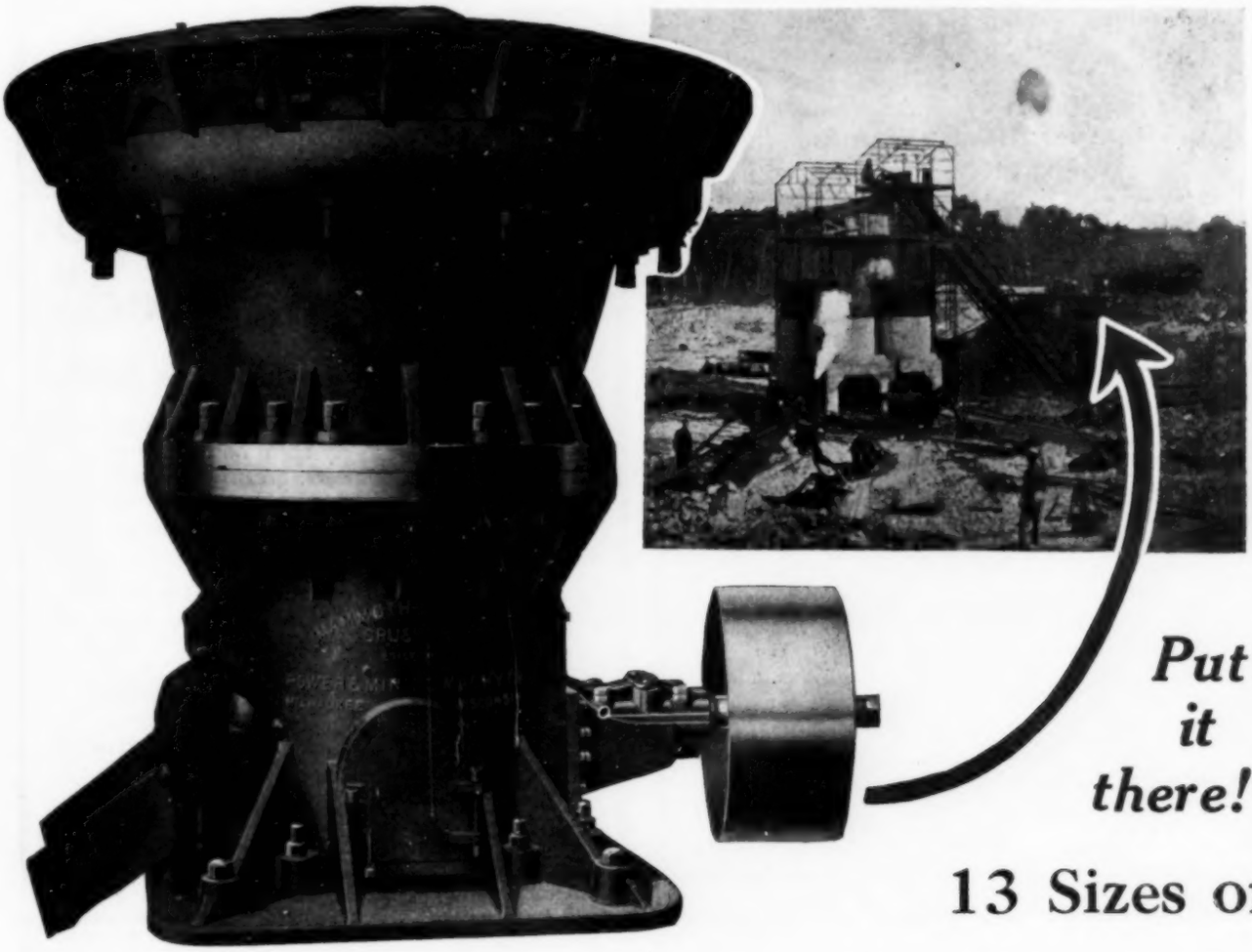
RESULT: Bartley Crucibles show a service factor which makes them economical "tools" in all crucible work.

Send for our literature. It covers all Bartley products—tilting furnace crucibles, retorts, stoppers, color bowls, etc.



JONATHAN BARTLEY CRUCIBLE COMPANY

TRENTON, NEW JERSEY, U. S. A.



Put it there!

13 Sizes of

McCully Crushers

From 4½ tons to 1300 tons per hour capacity

Our claims for this Crusher are as big and sweeping as the machine is important in metallurgical work.

Briefly we say that it is superior in efficiency, economy, design, materials and workmanship. Continuous crushing is accomplished by pressure—there is no abrasive action or possibility of heating.

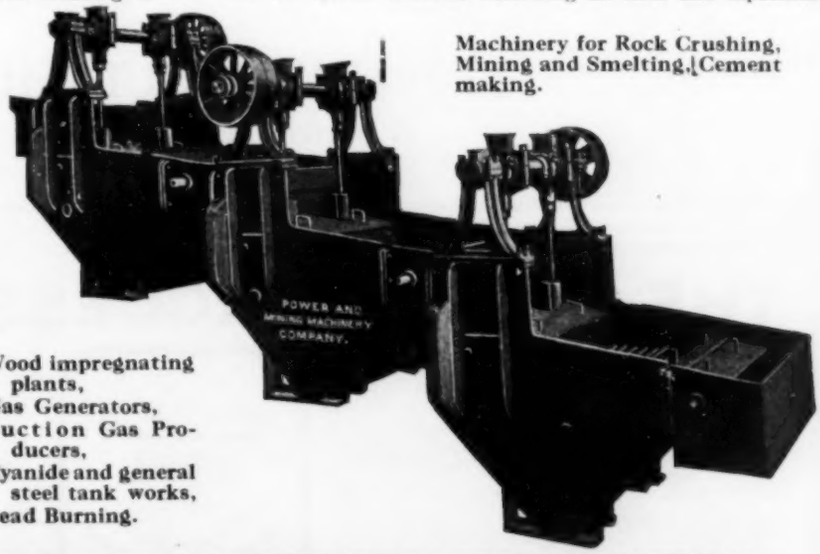
It is a highly dependable unit for the most severe work. Send for special bulletins describing all sizes and capacities.

Woodbury Jigs do not require sizing and classification of feed

The pulsations of the plunger are in the line with flow of pulp, instead of at right angles, resulting in uniform pulsation the entire width of sieve and a complete stratification.

They save floor space, power and water, and do away with the necessity of a number of screens.

The least expensive and most efficient system of jigging. Bulletin 40-71 contains description and list of users.



Machinery for Rock Crushing, Mining and Smelting, Cement making.

Wood impregnating plants,
Gas Generators,
Suction Gas Producers,
Cyanide and general steel tank works,
Lead Burning.

WORTHINGTON PUMP AND MACHINERY CORPORATION

115 Broadway, New York **Power & Mining Machinery Works, Cudahy, Wis.**

District Offices: CHICAGO EL PASO SAN FRANCISCO

W. E. AUSTIN MACHINERY CO., ATLANTA, GA.

M371.9

RIVERSIDE ACID WORKS
MANUFACTURERS OF
SULPHURIC ACID
MURIATIC ACID
HYDROFLUORIC ACID
SODIUM SULPHATE
OR SALT CAKE
CALCIUM SULPHATE
GEO. J. HESCH
GENERAL MANAGER
WARREN, PA.

"A Little Acid Is a Handy Thing"

The above parody on a well-known aphorism contains more truth than does the original model, which refers to a little knowledge.

The possibility of a complete lack of acid in the hands of our non-contract customers has been reduced by our practice of selling our reserve tonnage in the open market every thirty days.

We are not required to advertise this reserve in order to sell it, understand. The expense of this quarter page is borne by us solely to tell you that there is a possibility of your obtaining **some** acid at open market prices.

Neither can we consistently promise to fill your orders. We are only telling you about your opportunity.

G. J. H.

On your next Chemical Order—

Specify

"BAKER'S Analyzed"

Chemicals & Acids

After a trial you will specify them on ALL your orders, because you will find them dependable reagents of the highest quality and uniformity.

An Accurate Analysis Appears on the Label of Each Bottle.

Catalogue on Request

J. T. Baker Chemical Co.
Phillipsburg, N. J.

CRUDE SULPHUR

Guaranteed 99% Pure

For use in Metallurgical field, etc.

THE UNION SULPHUR CO.
17 Battery Place, New York City

THE SOLVAY PROCESS COMPANY

SYRACUSE, N. Y. — DETROIT, MICH.

MANUFACTURERS OF

SODA ASH . . In all commercial tests
CAUSTIC SODA . . In all tests

MONO-HYDRATE CRYSTALS,
1 lb. = 2½ lbs. Sal. Soda
SNOW FLAKE CRYSTALS,
1 lb. = 2 lbs. Sal. Soda

SOLE AGENTS

WING & EVANS, Inc. - - - 22 William St., New York

ABSORPTION

Reason No. 2* Why Laclede-Christy Chemical Rings and Tile Make Better Acid-Proof Packing for Towers.

In recent absorption tests made upon Laclede-Christy Chemical Tile, the following results were obtained:

Boiling in water three hours: Tile absorbed .0006383 per cent of water — only 6/100 of 1 per cent.

Soaking in water 48 hours: Tile absorbed .00106 per cent of water—only 1/10 of 1 per cent.

These remarkable results are further arguments in favor of Laclede-Christy acid-proof Tower Packing. The packing that will undergo such tests, absorbing less than 1 per cent of water, is surely the right packing for your towers.

Why not give Laclede-Christy Tower Packing a chance to make good for you? We will quote you promptly—tell us your needs.

We manufacture four styles of acid-proof packing—chemical rings, triangular brick, square brick and "A" Tile.

LACLEDE-CHRISTY CLAY PRODUCTS CO.
Manchester and Sulphur Aves., St. Louis, Mo.

**Reason No. 1—Large contact surface.*
Watch for Reason No. 3!

Milton Brick Company
Plant: Milton, Pa. New York Office, 47 W. 34th St.

SPECIALISTS IN
"Acid Proof" Shale Brick

Used by the U. S. Government and leading Chemical Companies, Refiners of Copper, etc.

Write for prices and samples of Milton SPECIAL "Acid Proof" Shale Brick, and Milton STANDARD "Acid Proof" Shale Brick.

Harbison-Walker Refractories Co.
Manufacturers of
High Grade Fire Clay Brick
Silica Brick Chrome Brick
Magnesia Brick
Importers of
Chrome Ore & Dead Burned Magnesite

General Offices—
Farmers Bank Building, Pittsburgh, Pa.

Liquid Sulphur Dioxide

Produced from Pure Sulphur

ANSUL CHEMICAL COMPANY
Marinette, Wisconsin

For bonding and repairing fire clay or silica brick work, tile, retorts, etc.

USE **HYTEMPITE** THE
High Temperature Fire Brick Cement.

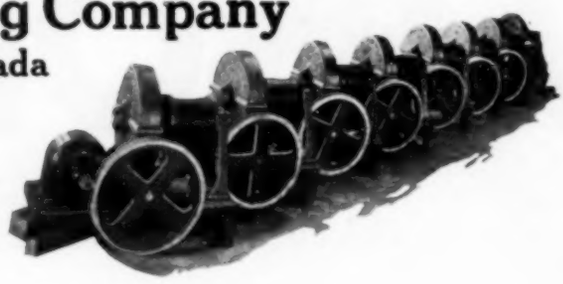
Quigley Furnace Specialties Co.
26 Cortlandt Street New York

The Volta Manufacturing Company

Welland, Ontario, Canada

Manufacturers of

Hand and Electrically Operated Winches
Automatic Regulators
Electrode Holders
Electric Furnace Accessories
General Consulting Work
Machines Designed and Built to Customers' Own Special Requirements



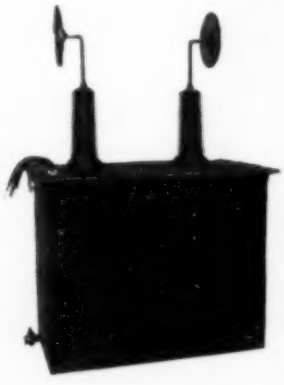
Address all inquiries to R. Turnbull, Box 416, Welland, Ontario, Canada

AMERICAN TRANSFORMERS

For Electro-Chemical and Electro-Metallurgical Processes

The majority of Transformer installations for the Cottrell System of Electrical Precipitation have been supplied by this company.
Our broad engineering experience on this and other applications of Electro-Chemical and Electro-Metallurgical processes should prove valuable to you. Send complete information for estimate.

American Transformer Company
151 Miller Street, Newark, N. J.



Tilting Reverberatory Furnaces

for Non-Ferrous Metals

(Melting without Crucibles)

For full description write for Catalog No. 22-C

W. S. ROCKWELL COMPANY
Furnace Engineers and Contractors
50 CHURCH STREET NEW YORK
Hudson Terminal Building

Low Voltage Generators

Up to 10,000 amperes

Single, two and three voltages for School and Laboratory work. Deposition, Refining and Separation of metals.

CHAS. J. BOGUE ELECTRIC CO.
513-515 West 29th, New York

JANTZ & LEIST

LOW VOLTAGE MOTOR GENERATORS
Uniform E. M. F.—150 to 8,000 Amperes
For Electrolytic Work, Electroplating, Etc.

CINCINNATI, OHIO

Thordarson Transformers

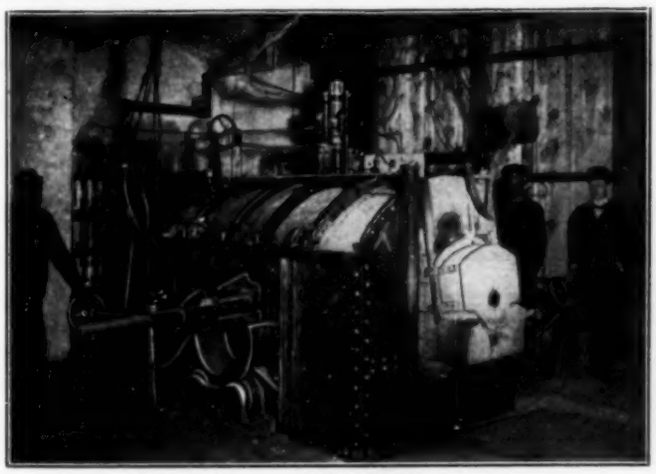
Specially designed and built for your needs. We specialize in transformers for Cottrell Process, Electric Furnaces, Laboratories, etc.

Thordarson Electric Mfg. Co.
Chicago, Ill.

Rennerfelt Electric Arc Furnaces

Solid bottom like an open hearth.

from 1/3 ton size up



Uses any kind of electric current.

Electrode consumption 2½ to 5 lb. per ton of metal.

.9 power factor with 60 cycles.

Making all different grades of steel today.

Also melting special grey iron — Brass — Copper — Nickel and Ferro-Manganese

83 Sold in Three Years and a half.

HAMILTON & HANSELL

17 Battery Place, NEW YORK

Chicago Office, GLEN B. HASTINGS, 1511 Lytton Bldg.
Pacific Coast Agents, Woods, Huddart & Gunn, 444 Market St., San Francisco; W. Montelius Price Co., 524 First Ave. South, Seattle, Washington.
Address Foreign Inquiries to A. B. Elektriska Ugnar, Stockholm, Sweden.

Concerning Motors

Almost every industrial plant, nowadays, uses motors to a greater or less extent.

Proper brush selection means much if they are to give efficient service.

If you could see the vast amount of data we have accumulated through co-operation with motor manufacturers you would appreciate the value of the service we are in a position to render you.

This collection of data has been going on for over a quarter of a century, so that we are in a position to render intelligent and efficient service on all brush requirements.

In order to furnish the proper service we have worked up a data sheet which, properly filled out, enables us to furnish the type of brush most suited to various machines.

Write for this data sheet.

National Carbon Company

Cleveland, Ohio

Carbon Manufacturers to the Industry

GIROD ELECTRIC STEEL FURNACES

are used in capacities up to 25 tons per heat by the most prominent makers of "special" steel. Among others will be found the

Bethlehem Steel Company

who are operating a ten ton (per heat) furnace. The Girod Furnace and Experience eliminate costly experiments.

C. W. LEAVITT & CO.

SOLE AGENTS

32 Church Street, New York

FERRO-ALLOYS—Low in Carbon

FERRO
- —Manganese, 80%
- —Silicon, 50%-75%
- —Chrome, 65%-70%
- —Molybdenum, 70%-80%
- —Tungsten, 70%-80%
- —Vanadium, 25%-30%, etc.
- —Phosphorus, 20%-25%

65-70% Ferro-Chrome (of the usual and lowest carbon contents) and "ELECTROMET BRAND" 50% Ferro-Silicon always in stock in this country for immediate delivery.

FERRO TUNGSTEN
70 to 80% Tungsten, Maximum 0.50% Carbon.

FERRO MOLYBDENUM
70 to 80% Molybdenum, Maximum 0.50% Carbon.

ORES
Chrome, Manganese, Iron, etc.

SPECIALTY:
"IMPERIAL CHROME ORE"

The Well-known Refractory Ore for Furnace Linings—Lumpy, Low in Silica and Low in Iron.

FLUORSPAR—Lump and Gravel

E. J. LAVINO & CO., BULLITT BLDG., PHILADELPHIA, PA.

Sales Agents for the U. S. and Europe for the Products of the
ELECTRO METALLURGICAL CO., NEW YORK AND PHILADELPHIA
WORKS: KANAWHA FALLS, W. VA., AND NIAGARA FALLS, N. Y.

ALUMINUM, SILICON-COPPER,
(For making solid, pure copper castings.)
Manganese Copper,

We will quote as cheerfully as we ship

Special Alloys to Order.

Experimental Work in Electro-Metallurgy.

THE ELECTRIC SMELTING AND ALUMINUM COMPANY
LOCKPORT, N. Y.

Union Carbide Company
People's Gas Bldg., Michigan Blvd., Chicago
42d Street Bldg., New York, N. Y.

MANUFACTURERS OF
Calcium Carbide

WORKS:
NIAGARA FALLS, N. Y. SAULT STE. MARIE, MICH.

Crude and Calcined
MAGNESITE
CHROME and MANGANESE
Buy direct from producers.
Write or Wire
LEVENSALER-SPEIR CORPORATION
253 Monadnock Building, San Francisco, Cal.

Manufacturers
TUNGSTEN PRODUCTS
Sodium Tungstate Tungstic Acid Tungsten Metal and Ferro-Tungsten
JEFFERSON TUNGSTEN CO.
1010 Jefferson St., Hoboken, N. J.

ATKINS, KROLL & CO., San Francisco
Import Merchants
SCHEELITE CONCENTRATES, 70%. DANISH FLINT PEBBLES, SILEX LINING, CYANIDE, QUICKSILVER, MINING CANDLES, FIREBRICK, BORTS AND CARBONS, BLACKSMITH COAL, COKE, IMPORTED FUSE, SUPERIOR QUALITY ZINC DUST.
Stocks Carried.
Buyers of Quicksilver and Platinum also Ores of Antimony, Bismuth, Molybdenum, Tungsten, Vanadium, Zinc, etc.

TITANIUM OXIDE
High grade RUTILE AND ILMENITE Concentrates for the manufacture of Titanium Alloys, Enamels, Pigments, Oxalates, Sulphates, Chlorides, etc.
AMERICAN RUTILE COMPANY
Pacific Building Washington, D. C.

MAGNESIUM
Manufactured in America
AVIATION MATERIALS CORPORATION
99 Cedar Street, New York City

The Wise Agitating Sulphur Burner
(Patented United States and Canada)
Efficient Simple Durable
Prompt Deliveries
Carthage Machine Co. **Carthage, N. Y.**
(Sole licensed manufacturers)

FERRO CARBON — TITANIUM
The Final Cleanser and Deoxidizer—For all Steels
TITANIUM ALLOY MANUFACTURING COMPANY
Operating Under Rossi Patents
Processes and Products Patented
TPC Reg. U. S. Pat. Off. TRADE MARK.
General Office & Works: Niagara Falls, N.Y.
Pittsburgh Office: Oliver Building
Chicago Office: Peoples Gas Building
New York Office: 15 Wall Street
AGENTS:
Great Britain and Europe: T. Rowlands & Co., Sheffield, Eng.

Superfine
Zinc Dust
Any Mesh Highest Purity
METALS DISINTEGRATING COMPANY, Inc.
3 So. William St., New York Tel. Hanover 377

Ferro-Uranium

The Latest Discovery in Alloys for Efficient

HIGH SPEED

and other

STEELS OF QUALITY

It insures tools that

STAND UP ON THE JOB

Largest Producers in the world of URANIUM

Write Us for Particulars

STANDARD ALLOYS COMPANY

Forbes and Meyran Aves. PITTSBURGH, PA.

1½%

Of 99% Pure Metallic Magnesium doubles tensile strength and quadruples resistance to shock in an aluminum casting. This increase in strength means from 25% to 50% reduction in casting weight. The result is a casting lighter than aluminum, stronger than aluminum, and much easier to finish. And by using

99% Pure Metallic Magnesium

you cut machining costs in two by halving the number of resets on the cutting tool, permitting polishes without a separate operation.

We supply 99% Pure Metallic Magnesium in Ingots, but it can be delivered in pulverized form if desired. Let us quote on any quantity.

The Norton Laboratories, Inc.

Lockport, N. Y. Nashua, N. H.

ESTABLISHED OVER FORTY YEARS

SPECIALISTS IN

UNUSUAL ORES

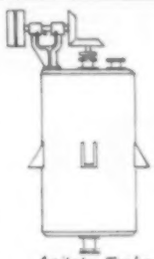
MANUFACTURERS OF MINERAL PRODUCTS

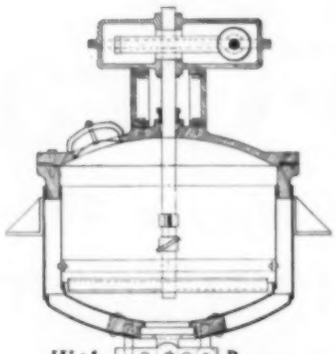
FOOTE

MINERAL COMPANY INCORPORATED

109 N. 19TH ST. PHILADELPHIA (CABLE "FOOTE PHILADELPHIA")

"MONTHLY PRICES" MAILED FREE ON REQUEST

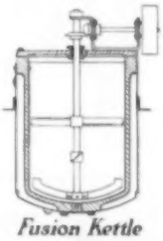

Agitator Tanks built to specifications

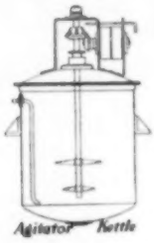

High Pressure Mixing Kettle

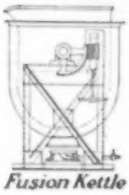
Open Fired Mixing Kettle

Vat

Cast Iron and Plate Steel Stills Single or double

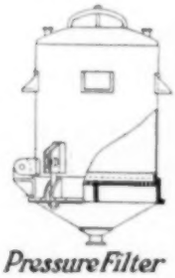

Fusion Kettle

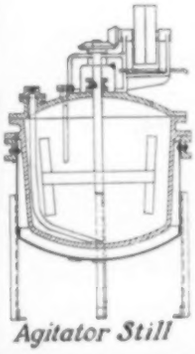

Agitator Kettle

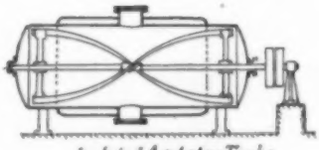

Fusion Kettle

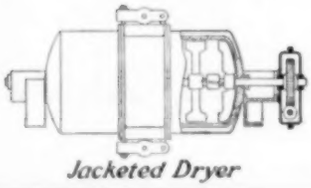
Chemical Apparatus of all types.
Various sizes of tanks in stock.

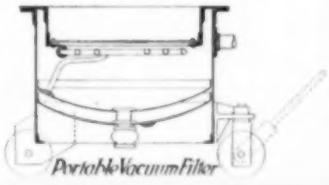
Stevens-Aylsworth Company 90 West Street New York City

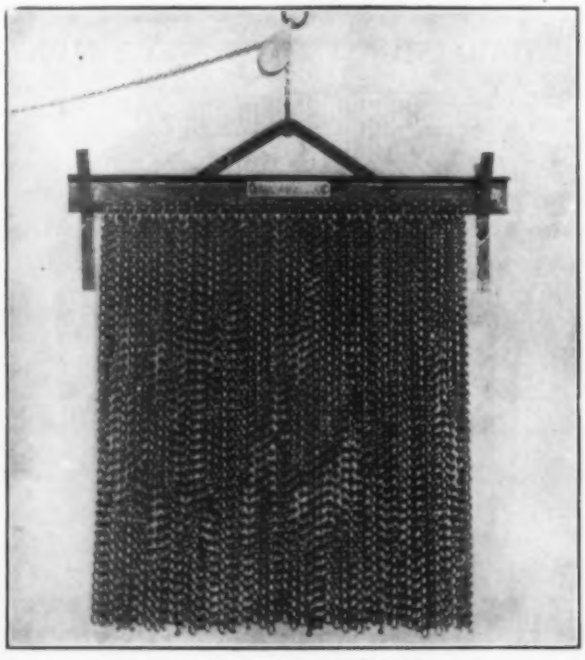

Pressure Filter


Agitator Still


Jacketed Agitator Tanks for pressure or vacuum


Jacketed Dryer


Portable Vacuum Filter



WIEGAND PATENT

Chain Screen Doors

Protect the work from chill and the workmen from heat, glare and sparks. Used on all furnaces.

E. J. CODD CO.
700 S. Caroline St., Baltimore, Md., U. S. A.

SINTERING

FINE ORES AND CONCENTRATES

FOR THE BLAST FURNACE IS STANDARD PRACTICE

Dwight & Lloyd Sintering Co.
INCORPORATED
29 Broadway, New York
CABLE ADDRESS, SINTERER

The October Issue Contains:

THE GLACIAL EPOCH
By THOMAS P. ROBERTS, Civil Engineer, U. S. Engineer Office, Pittsburgh, Pa.

SOME ASPECTS OF THE TESTING OF REFRACTORIES
By A. V. BLEININGER, Ceramic Chemist, U. S. Bureau of Standards, Pittsburgh, Pa.

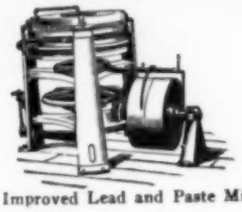
The November Issue Contains:

DESIGN OF SYMMETRICAL HINGELESS CONCRETE ARCHES
By VICTOR H. COCHRANE, Engr. of Bridges, City of Kansas City, Kansas City, Mo.

NEW MINING METHODS AS PRACTICED BY THE H. C. FRICK COKE CO.
By PATRICK MULLEN, Mine Inspector, H. C. Frick Coke Co., Scottdale, Pa.

PROCEEDINGS
The Engineers' Society of Western Pennsylvania
50 cents per copy. $5.00 per year.
ELMER K. HILES, Secretary, 2511 Oliver Bldg., Pittsburgh, Pa.

GRINDING MILLS



Improved Lead and Paste Mill

Disintegrators, Dryers
Chasers and Machines for

LABORATORY & FACTORY

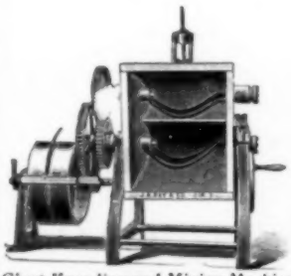
Plans and Estimates for

SPECIAL MACHINERY

Promptly Furnished

THE J. H. DAY CO.

Office and Factory: Cincinnati, O.



Giant Kneading and Mixing Machine

Write for Catalog showing complete line of Mills and

MIXING MACHINES

Highest Quality

Ferro Tungsten

Do You Analyze Your Ferro-Tungsten?

If Not, It Would Pay You To Do So—

The value of a product is largely controlled by the purity of the materials of which it is made.

We Guarantee —
Our Ferro-Tungsten to this analysis:

Tungsten	70 to 80%
Carbon—not over	½%
Sulphur—not over	.05%
Phosphorus—not over	.08%

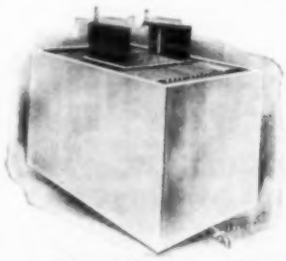
Our facilities are of the very best due to a strictly modern plant and equipment. We are able to offer quick deliveries. Write, Wire or Cable for prices.

THE VANADIUM-ALLOYS STEEL CO.

LATROBE, PENNA.

Makers of "Red Cut Superior"—A Quality High Speed Steel

Electrolytic Cells

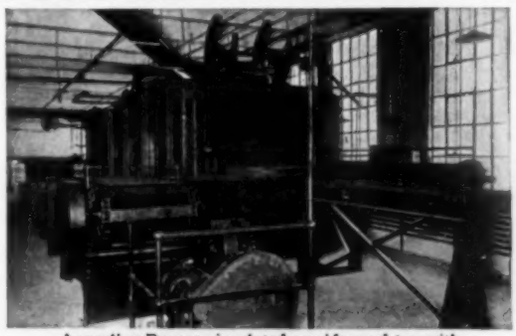


For the production of *Sodium Hypochlorite* from salt. For bleaching paper pulp, textiles, gun cotton, purification of drinking water, etc.

Write for catalogue and prices.

The Electro Chemical Company

DAYTON, OHIO



Annealing Furnace insulated on sides and top with

SIL-O-CEL

PREVENTS HEAT PENETRATION

TRADE MARK

MADE FROM CELITE

IN high temperature furnace work, uniform temperature and minimum fuel consumption are essential. This can best be accomplished by insulating the sides, top and bottom of furnaces with Sil-O-Cel Insulating Brick or Powder.

Kieselguhr Company of America

Producers of Celite

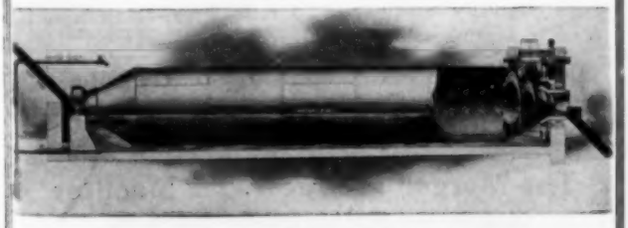
NEW YORK: 11 Broadway
PITTSBURGH: Oliver Bldg.
CHICAGO: Monadnock Bldg.
LOS ANGELES: Van Nuys Bldg.
SAN FRANCISCO: Monadnock Bldg.
KIESELGUHR CO. of CANADA 61 Sumach St., Toronto

KIESELGUHR COMPANY OF AMERICA:
Please send samples and book to

Name .....
Business .....
Address .....
....MC 30

THE BAKER COOLER

Applicable to metallurgical and industrial calcines
Saves Power Water, Dust and Headroom



Recent orders received:

The Norton Company (repeat)
Aluminum Co. of America
Empire Zinc Co. (repeat)
Daly-Judge Mining Co.

THE STEARNS-ROGER MFG.CO.

Denver, Colo.

Why Make Patterns?

Whether you want *one gear* or *one hundred*, why go to the *expense* of *making patterns?* We can furnish you *machine molded gears* and *save you pattern expense.*

By the Machine Molding Process all the teeth in a gear are molded from a single tooth pattern, the spacing being done by accurate machinery.

A machine molded gear is, therefore, more accurate, better balanced and as nearly perfect as a cast tooth gear can be made.

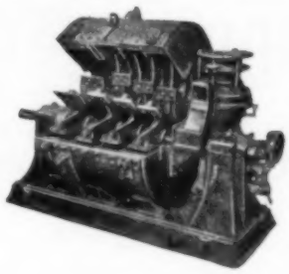
SPUR, BEVEL, MITER and WORM GEARS machine molded—1″ to 6″ pitch.

MORTISE WHEELS with dressed teeth and cogs.

We are equipped to furnish gears with *Machine Cut Teeth.*

Our catalog lists the gear you want. Over 100 pages of gear lists and useful information. Have you a copy?

H. W. CALDWELL & SON CO.
CHICAGO: 17th St. and Western Ave.
DALLAS, TEXAS: 711 Main Street
NEW YORK: 50 Church Street.



THE AERO
Pulverized Coal System

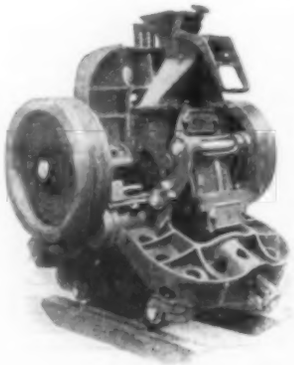
is a *Unit System.* The Pulverizer and the furnace is the unit. There is nothing between them but a plain iron pipe.

The AERO is a no-storage system and therefore free from fire and explosion hazards. Coal drying is optional.

The pulverizing, mixing and feeding operation, as well as the furnace, are at one time under the eye of one man.

Write for Bulletin.

AERO PULVERIZER CO.
Equitable Bldg., New York



Most Economical Grinding

FROM RESULTS OBTAINED BY OUR CUSTOMERS WE ESTIMATE THE CAPACITY, AS FOLLOWS, OF THE

MAXECON MILL

Limestone	4 tons per hour to 95%	100	mesh
Florida Pebble	7 tons per hour to 90%	60	mesh
Bauxite	4 tons per hour to 95%	100	mesh
Hardest Ores	5 tons per hour to 90%	50	mesh
Coal	4 tons per hour to 95%	100	mesh
Silica	2 tons per hour to 95%	200	mesh
Cement Clinker	10-12 bbls. per hour to 98%	100	mesh

With Under 25 H. P. Minimum Wear and Repairs

Used as a Standard Grinder by the United States Steel Corporation, Aluminum Company of America, Pennsylvania Salt Manufacturing Company, Virginia Carolina Chemical Company and practically universally in the chemical fertilizer factories of the United States and Europe. **Send for Bulletin 36.**

KENT MILL CO., NEW YORK, Borough of Brooklyn, 10 Rapelyea St.
BERLIN, Berlin-Hohenschoenhausen.
LONDON, 31 High Holborn.

RUSSELL ENGINEERING CO.
High Temperature Furnace Work
Consulting, Designing, Construction, Special Industrial Furnaces, Chemical Re-action Furnaces, Oil Burning Furnaces, Muffles, etc.
International Life Building, St. Louis, Mo.

SMITH SECTIONAL GAS PRODUCERS
Clean, cold producer gas in unlimited quantities

High in quality and uniform in heating value.

The Smith System produces a tar-free gas—a clean fuel for particular manufacturing processes.

THE SMITH GAS ENGINEERING CO., Lexington, O.

CONNERSVILLE
Blowers, Gas Pumps, Water, Vacuum and Liquor Pumps.
THE CONNERSVILLE BLOWER CO.
Connersville, Ind.
Chicago, 929 Monadnock Blk. New York, 114 Liberty St.

The Morgan Producer Gas Machine

is the highest class gas producer built in the U. S. and is advertised in the 1st of the month issues of this journal.

Morgan Construction Co.
Worcester, Mass.

Elevator Buckets

Malleable Iron

Style A—for ord nary service

Standard Design

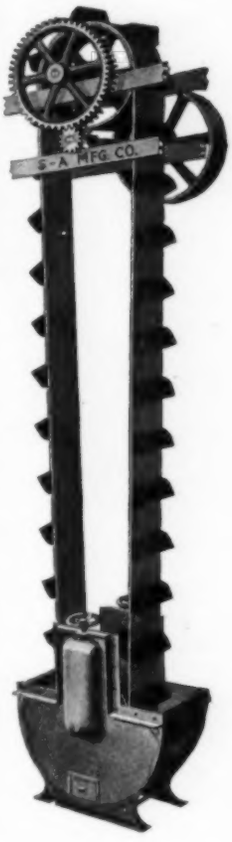
Style AA—with reinforced lip for severe service

The proper bucket for carrying

Ore Cement Stone
Ashes Phosphates Sand
and other abrasive materials.

The Webster M'f'g Company

Chicago Tiffin, Ohio New York
(160)



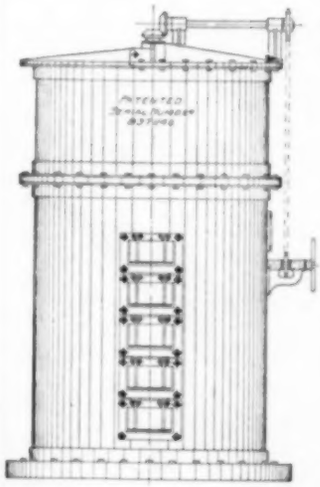
"S-A" Bucket Elevators

This common type of mill equipment is but one branch of our complete line of material handling machinery. In order to adapt this machinery to the individual requirements of our various customers we maintain a corps of experienced conveying engineers.

Let us study your present requirements.

Stephens-Adamson Mfg. Co.
Aurora, Ill.

BRANCHES:
New York, Chicago, Pittsburgh, St. Louis, Detroit, Huntington, W. Va., Boston, Salt Lake City, Toronto, Ont.



"Vesuvius" Sulphur Burner

Burns any kind of sulphur, no matter how dirty.
Has capacity of three rotary burners and uses only one-fourth the floor space. No power required—no repairs necessary. Cleaning required less often, and takes less time.
No hand firing except to start.
No auxiliary melting equipment.
A known success from actual service.
Laboratory size to nine-ton capacity.
Write for booklet, tests, etc.

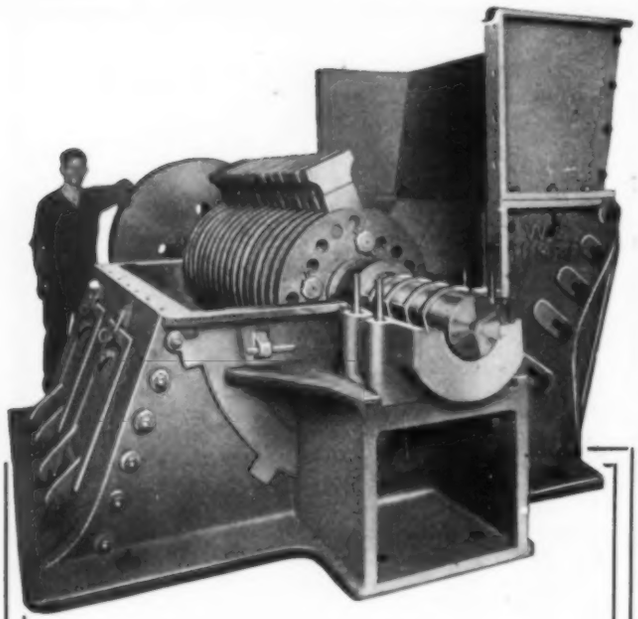
Valley Iron Works Co.
Appleton, Wis.

TRAYLOR'S

Heavy Grey Iron, White Iron and Semi-Steel Castings for ALL PURPOSES ARE BEST

Prompt Deliveries
Send us your Inquiries

Traylor Engineering & Mfg. Co.
Main Office and Works:
Allentown, Pa., U. S. A.
New York Office: 28 Church St. Western Office: Salt Lake City, Utah



ADAPTABILITY

Whether for crushing, grinding, or shredding; whether you wish to handle soft or hard material; whether a fineness of 100 mesh or a product 2" and under is desired; or a capacity of 100 lbs. or 300 tons per hour—

WILLIAMS

is able to meet your requirements. Williams crushers, grinders and shredders are the most versatile machines manufactured and are adaptable to nearly all materials which it is necessary to reduce—over 600 in number. We have subdivided the various materials into eight divisions as per tables below. Please specify catalog desired by number.

NO. 18	NO. 18-A	NO. 18-B	NO. 18-C
Limestone Lime Gypsum Coal Ochres Dry Colors	Shale Clay Asphalt Sand All Clay Material	Tankage Bone Shells Poultry Food and all Fertilizer Material	Oil Cake Linseed Cotton Seed Castor, Nitre Salt Cake Soy Bean Copra, Etc.
NO. 18-D	**NO. 18-E**	**NO. 18-F**	**SPECIAL**
Stock Food Cereals Alfalfa and all By-Products from Flour Mills	Coal Crushers for Coke Ovens Gas Plants and all Industrial Plants	Shredders Bark, Chips Wood Pulp Licorice Root and all Fibrous Material	Soap Powder All Drug Material Paper Stock and all Chemicals

THE WILLIAMS PATENT CRUSHER & PULVERIZER COMPANY

GEN. SALES DEPT., OLD COLONY BLDG.

CHICAGO

Plant: ST. LOUIS

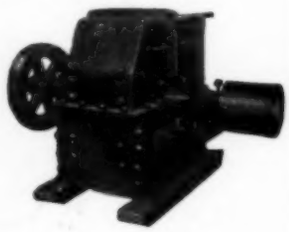
263 Market St., SAN FRANCISCO

The All-Steel K-B PULVERIZER

saves power costs

It will economically reduce all moderately hard materials from 3" to dust in one operation. The patented hammer adjustment permits you to regulate the fineness of your product.

The K-B will resist the hardest service. It is built entirely of steel, and in addition, manganese steel lining plates protect the frame from all wear. Gives a uniformly fine product.



Write to us for figures regarding the capacity and power required for crushing your material. Ask for Bulletin M.

K-B Pulverizer Co., Inc.

Philadelphia Office: 502 North 19th St.

86 Worth Street, New York City

BUILT FOR SERVICE AND DURABILITY

MEAD MILLS

Mead Mills are of the high speed disc type, reducing the material by impact. In design and construction they represent the highest achievement in grinding machinery. The beaters are made of hand forged tool steel, constructed and attached to give the greatest cutting power. These mills can be regulated to give the desired degree of fineness.

Send for catalogue and complete information.

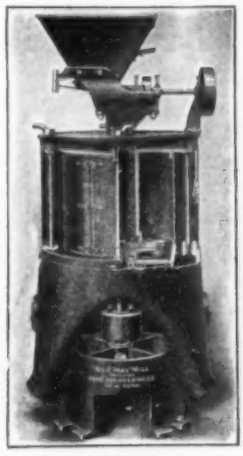
MEAD & COMPANY

Detroit, Michigan, U. S. A.

The following are a few of the prominent manufacturers using Mead Mills:

American Car & Fdry. Co.
American Glue Co.
American Chicle Co.
American Graphophone Co.
American Crayon Co.
American Agric'l Chem. Co.
Clinchfield Products Corp.
Cudahy Packing Co.
Durex Chemical Co.
Dunlop T. & Rub. Goods Co.
Eastern Tanners Glue Co.
Goodyear Tire and Rub. Co.
B. F. Goodrich Co.
Mallinckrodt Chemical Wks.
National Roofing Co.
Pathe Freres Phonograph Co.
Standard Aniline Prod., Inc.
Sherwin-Williams Co.
Toch Brothers
Parke Davis & Co.

Grind, Crush Comminute at Less Cost



Improved "Max" Mill (Patented) for Grinding Nitre Cake, Arsenate of Lead, Salts, Lime, Sugar, etc.

Our patented improved machines will effect important economies in your work in three ways:

They require less expert attention.

They are practically trouble-proof, and thus eliminate shutdowns for extensive repairs.

The resulting product is of a finer and more easily marketable character.

Talk it over with our Staff

Our laboratories at your service without cost. We want you to learn the possibilities of improvements in your work.

We build and constantly carry in stock Ball Mills, Pebble Mills, Jar Mills, Cutters, Crushers, Laboratory Mills, Disintegrators, Pressure Blowers, High Vacuum Pumps, Vacuum Heating Pumps, Mixers, Sifters, Filter Presses. Send for Illustrated Bulletins.

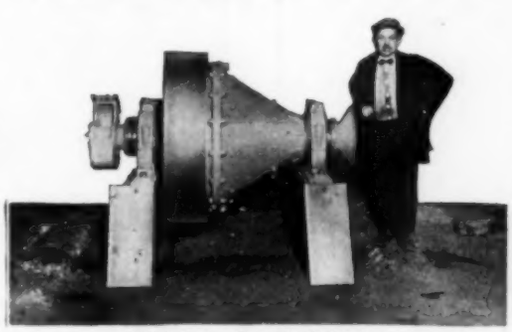
ABBÉ ENGINEERING COMPANY

218-220 Broadway, New York City

Takes a coarse feed
Delivers finished material
One operation—no screening

THE HARDINGE MILL

In this progressive age there is no greater exponent of improved ways to do things than the Hardinge Mill, which cuts the cost of grinding, pulverizing and granulating to a minimum by its **continuous discharge** of ground material—as fine as 100 mesh if desired.



3 Feet by 8 Inch Cylinder
The only successful small continuous mill

The relation of continuous to intermittent grinding is a subject which deserves the close attention and study of all who operate Ball or Pebble Mills. Get the whole story of the Hardinge Mill (Capacities from **300 lbs.** to **33 tons** per hour).

HARDINGE CONICAL MILL CO.

London Office:
SALISBURY HOUSE

120 BROADWAY, NEW YORK

Cable Address:
Hallharding, NEW YORK

V. A. STOUT
California Sales Agent
Balboa Building, San Francisco, Cal.

CHEMICAL CASTINGS

40 Years' Experience

We solicit business from concerns who appreciate **service** based on the **quality** which comes from **long experience.**

We have the experience. The quality is in our castings. You can rely upon us for the service that means steady satisfaction, as our many old customers in the chemical field can testify.

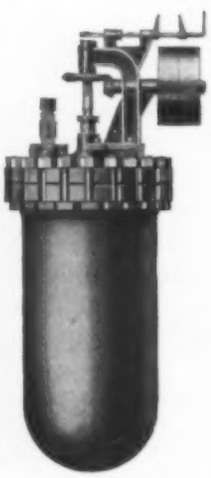
Special Machine Work **Acid Castings, Acid Eggs, Caustic Pots, Kettles, Stills, Retorts**

In our own well-equipped machine shop we take care of all special machine work. Machinery built to order. Write us.

THE FULTON FOUNDRY COMPANY
Cleveland, Ohio

AUTOCLAVES

Plain or Mechanically Stirred



Aniline, Dehydrating and Crystallizing Pans

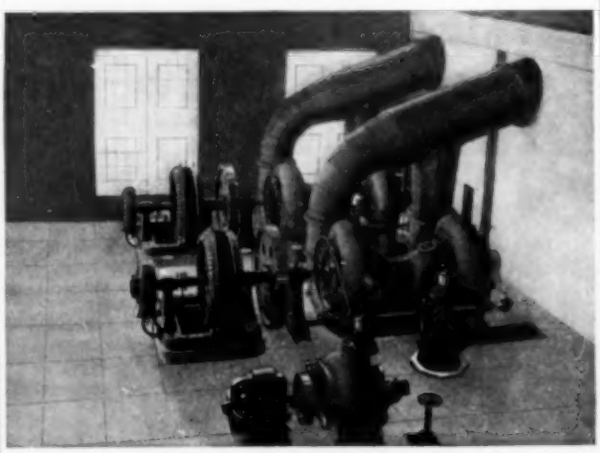
Boiling, Sulfonation, and Fusion Kettles

Melting and Decomposing Pots

Nitric Acid Retorts and Stills

"Ajax" Rocking Grates

VALLEY IRON WORKS
Williamsport, Pa., U. S. A.



Pelton Water Wheels

(in both the tangential and turbine types) are the acknowledged standards for hydro-electric transmission work.

The reason for this is simple: The selection of water wheel equipment is an engineering problem involving a number of special considerations. Our engineers have the special training and experience that assures a successful design and installation. Electro-chemical engineers are invited to put their hydraulic power plant problems up to us.

The Pelton Water Wheel Company
2187 Harrison St., San Francisco **95 West St., New York**

Do Your Causticizing Continuously with Dorr Agitators and Thickeners

If you will investigate **Dorr Agitators** and **Thickeners** in the causticizing industry, you will be convinced that their installation in your plant will not only reduce your operating cost but will increase your causticization and recovery as well.

What Dorr equipment has done for others it will do for you. At one plant, where continuous causticizing was installed, a 15° Be. liquor was produced with a causticity or conversion of 93%, and a recovery of 99.5% was obtained.

Durability, low cost, minimum repairs and maximum simplicity are all strong features in Dorr equipment.

Write for our new catalog

Continuous Counter-current Decantation for the Chemical Industry

THE DORR COMPANY
ENGINEERS

NEW YORK
17 Battery Place

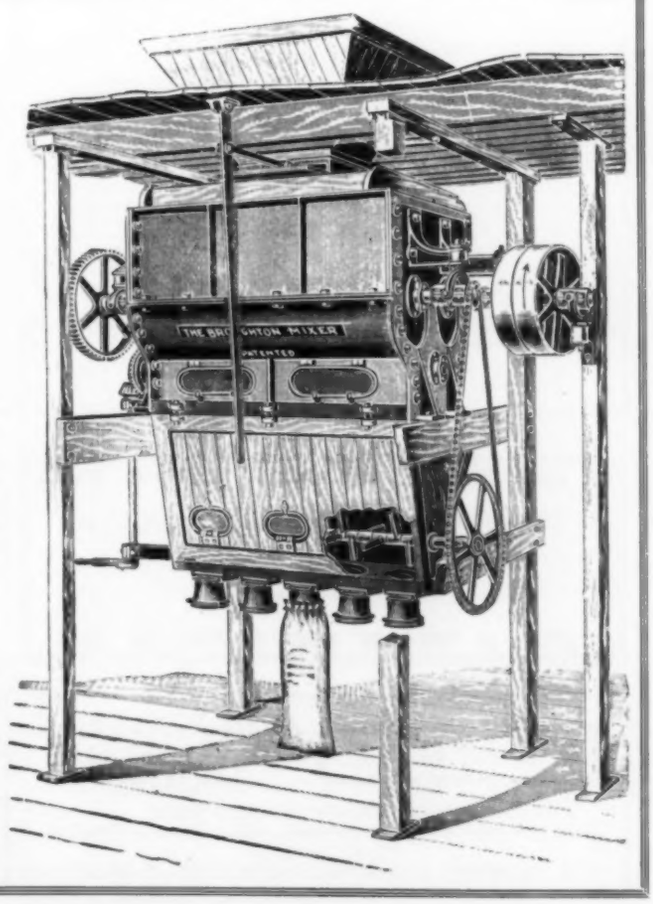
DENVER
1009 17th Street

LONDON, E. C.
16 South Street

A good mixer

gets the fat prizes in this world, and likewise, because it is a good mixer, the rich rewards of industry fall to the operators of the

Broughton Mixer



It mixes—steadily, thoroughly and without interposing those obstacles which often develop between the mixing hopper and the bag. If your business includes the incorporation of various materials, often of a widely different nature, you can appreciate what it means to have your mixing department *trouble-free*, as they will be if you use the Broughton.

The book gives reasons. Return the coupon.

W. D. Dunning, Syracuse, N. Y.

W. D. Dunning, Syracuse, N. Y.
Please send it free—your book on "Better Mixing."

Name .....

Address .....

.....

BETTER MIXING

Moses, Pope & Messer, Inc.
Industrial Engineers
366 Fifth Avenue
New York City

WE offer the combined services of Industrial Engineers and Chemists. Our organization will carry on the construction of your plant from foundation to finished product in the shortest possible time.

Our chemists and complete chemical laboratory will undertake research work in connection with new processes or the development of existing processes.

Southern Office:
A. Langstaff Johnston, Jr., M. E., E. E.
Mutual Assurance Society Building, Richmond, Va.

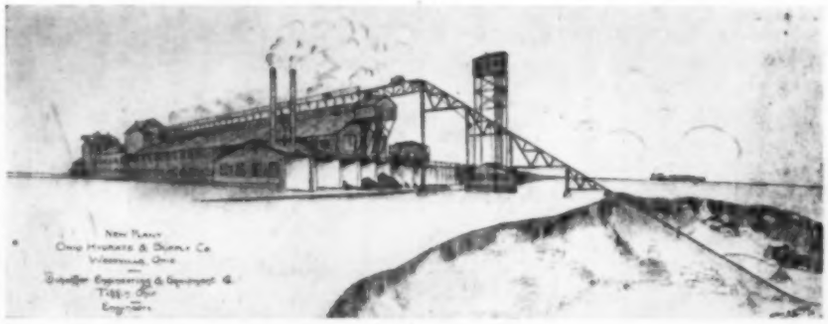
Canadian Office:
Alan Sullivan, C. E., M. E., Excelsior Life Building
Toronto, Ontario

Remarkable
Economy of Space
and
Cost of Operation
are the
main features of
S.B.B. All-Automatic Gas Filters
besides other material advantages

Write for Bulletin D242. Inquiries solicited

Simon, Buhler & Baumann, Inc.
29 Broadway, New York

REPRESENTED BY:
Clark Dust Collecting Co., 1116 Fisher Building, Chicago, Ill.
F. L. Jorgensen, 226 Engineers Bldg., Cleveland, Ohio.
P. Kranefeld, 1707 Franklin Street, Denver, Colo.



One of the
Schaffer Engineering & Equipment Company's Plants
(Now being constructed)

We are specialists in the design and construction of heavy duty automatic plants for the Cement, Fertilizer, Lime Industries, etc.

The Schaffer Engineering & Equipment Co.
Tiffin, Ohio

The Sharples Specialty Company
CENTRIFUGAL ENGINEERS
Westchester, Pa.

U. S. Blow Pipe and Dust Collecting Co.
Dust Collecting Engineers and Contractors
Send for new Catalogue.
2090 Canalport Avenue, CHICAGO, ILL.

ELMORE ACID RESISTING CENTRIFUGAL PUMPS
VOLUTE CUT OUT OF SOLID WOOD
Bronze Parts, Outlast Several Solid Bronze Pumps—Sizes To 12 in.
G. H. ELMORE, *Engineer* PHILADELPHIA—SCRANTON

THE IMPROVED EQUIPMENT CO.
80 Wall Street, New York City
COMBUSTION ENGINEERS
DESIGNERS AND BUILDERS OF
COMPLETE GAS PLANTS
LIME BURNING PLANTS
GAS BENCHES
GAS PRODUCERS
SPECIAL INDUSTRIAL FURNACES

Mechanical Apparatus for the Manufacture of Benzol, Toluol Aniline Dye Products Picric Acid Acid Resisting Castings

Long experience in chemical work enables the selection of Cast Iron best fitted for any specified service.

Samuel L. Moore & Sons Corporation
Elizabeth, N. J.

Webster Air Conditioning Apparatus

Complete equipment designed and furnished for improving working conditions or volume and quality of output by

Air Cleansing Dust Removal
Reclamation of Materials
Humidifying De-Humidifying
Low Temperature Drying

Results Guaranteed No problem in our line is too difficult for us to solve

Warren Webster & Co.
Main Office and Works **Camden, N. J.** Point and Pearl Sts.
Established 1888
Branches in Principal Cities

THE KALBPERRY CORPORATION

ROBERT S. PERRY, President — PAUL W. WEBSTER, Vice-Pres't and Treas.
FRANKLIN H. KALBFLEISCH, Chairman

31 UNION SQUARE, WEST NEW YORK, N. Y.

Investigation of proposed chemical and metallurgical investment and determination of its commercial desirability and financial soundness.

Examination of existing plant for efficiency of process, method and apparatus.

Design and supervision of chemical and metallurgical plant construction, initial operation and training of operatives.

Complete Designs and License for

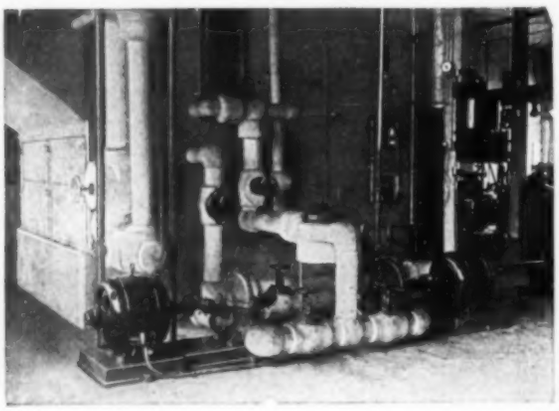
THE KALBPERRY TOWER SULPHURIC ACID CONCENTRATOR

60° 66° 97%

The tower that has proved an unqualified success in handling clean or dirty acid. Quickly constructed from standard stock materials at low first cost, and cheaply operated.

Adopted and working in many acid plants.

It will be our pleasure to answer your inquiries



The Making of Time Fuses for Shrapnel—A Severe Test for the Carrier Dehumidifier

Time fuses must be capable of setting for explosion of the shell anywhere from within 16 feet of the muzzle of the gun to a distance of several miles away, while the shell is traveling at a velocity of 1700 feet per second, or about 20 miles per minute. Two shells set for exploding at one mile and fired consecutively, must function within 40 feet of each other. The powder used in a time fuse is very hygroscopic, and the accuracy of firing is absolutely dependent upon conditioning the powder. The humidity of the atmosphere in which the fuse is loaded must therefore be maintained within a total variation of less than two per cent.

For providing the necessary amount and regulation of humidity in this delicate work no less than twelve of the leading American ammunition makers called upon us to design and install suitable humidifying plants, a typical one of which is shown above.

The fact that such important corporations turning out a product so closely inspected before acceptance, should come to us for engineering advice and apparatus, would seem to confirm our position of pre-eminence in the field of air-conditioning.

Further repeat orders (references on request) from other leading American and European manufacturers also indicate that our guarantees are fulfilled.

Tell us what humidity, temperature, air purification and regulation you require and we will send literature and, if you want it, free engineering advice.

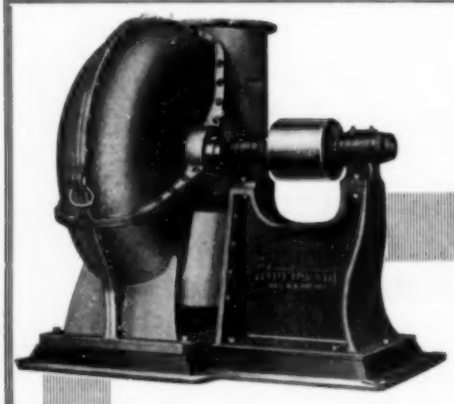
Carrier
Engineering Corporation

Carrier AIR CONDITIONING AND DRYING EQUIPMENT

39 Cortlandt St., New York

Boston 176 Federal St. | Buffalo Mutual Life Bldg.
Philadelphia Land Title Bldg. | Chicago Transportation Bldg.

34



Special Fans for the Chemical Industry

Sturtevant Regulus Metal Exhausters are specially designed for use in laboratories and industrial plants, as they resist the corrosive effects of acid and other gases. The most common acid gases handled are sulphuric, sulphurous, hydrochloric, chloric, and under some conditions, hydrofluoric. The lower oxides of nitrogen are also handled. These are built of various sizes and capacities and are of a lead alloy of high tensile strength. Great care is shown in the design of the various details so that the apparatus will give satisfaction when used in the chemical plant. Note removable segment which readily permits inspection of the wheel.

Our Engineering Department and our Chemical Laboratories are at your disposal for co-operation and advice and will recommend without charge the fan best suited to your requirements.

B. F. STURTEVANT CO.
HYDE PARK, BOSTON, MASS.
And All Principal Cities of the World
FANS FOR EVERY PURPOSE

Tell Us Your Dust Troubles

Automatic Recovery of Valuable Solids or Dust from Gases at any Temperature.

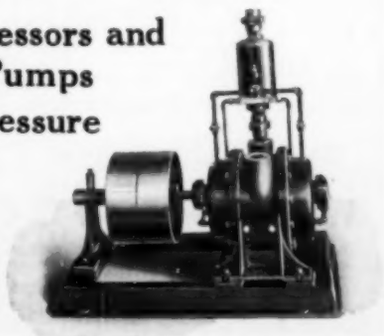
We solve any Dust Problem on any kind of Dust — under any circumstances and conditions.

Our Specialties—Combined Dry and Wet Centrifugal Systems on Kilns—Dryers—Ore Roasters and Furnaces—Cloth Filter Machines—Turbo Gas Washers.

The Clark Dust Collecting Co.
Fisher Building Chicago, Ill.
DUST COLLECTING ENGINEERS

CROWELL

Air Compressors and Vacuum Pumps
Positive Pressure Blowers



Crowell Manufacturing Co.
290 Taaffe Place
Brooklyn, N. Y.

96 MORSE Rarefied Dust Collectors

Sold to 8 Companies

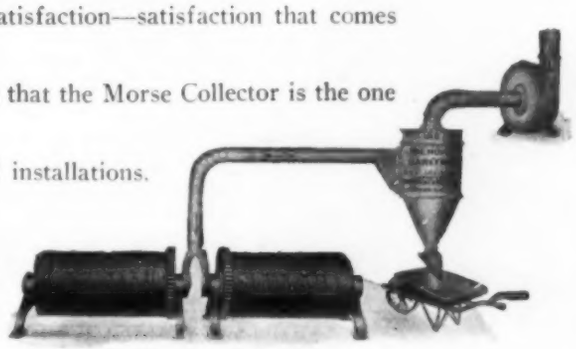
Weston-Mott Co. 12	Western Electric Co. 12	Oliver Chilled Plow Works . . . 9	Solvay Process Co. 18
Willys-Overland Co. 10	Westinghouse Elec. & Mfg. Co...14	Pittsburgh Plate Glass Co. . . . 9	General Electric Co. 12

88 Were Repeat Orders

A repeat order is the most eloquent expression of satisfaction—satisfaction that comes from efficiency, economy and durability.

Doesn't recognition of this character convince you that the Morse Collector is the one you need for your plant?

Send for booklet on "Dust Collectors" and list of installations. Also tell us what process of air cleaning you use.



The Knickerbocker Company
Jackson, Michigan

"NIAGARA" CONOIDAL FANS

for

Steady, Reliable Flow
High Speed
High Efficiency

For Ventilation, Heating or Drying work we have claimed this to be the strongest, most efficient and most reliable fan on the market.

Its record has so far given us no reason for qualifying these claims in the slightest. Read Catalog No. 201-55.

Buffalo Forge Company
BUFFALO, N. Y.
Branches in all large cities

Lessons of 1916

KEMETALINE

for your acid-proof pipe, valves and fittings

Profit by the latest and most advanced thought that has been applied to your industry.

Don't repeat the errors of 1916. Buy Valves, Iron Pipe and Fittings lined with KEMETALINE, the material that is *proof* against corrosion, has a smooth interior surface, and is inseparably bonded to the metal it protects.

Then your pipe lines will be as good at the close of a year as they were when you installed them. Save in first cost, repairs and the losses of interrupted production.

Know how good KEMETALINE is for resisting rotting in corrosive liquors. Write.

Chadwick-Boston Lead Co.
162 Congress St., Boston, Mass.

"ANTI-HYDRO"

MAKES CONCRETE PITS WATERPROOF
ACID AND ALKALI RESISTING

OVER FIFTY PITS (averaging 50′ x 15′ x 10′) of reinforced concrete, hardened and waterproofed by the addition of "Anti-Hydro," have in the past year been successfully constructed in the salt water meadows and on the river fronts for chemical and other plants. An average seven-foot water pressure had to be overcome, along with many acid and alkali difficulties. Every pit has proven itself perfect.

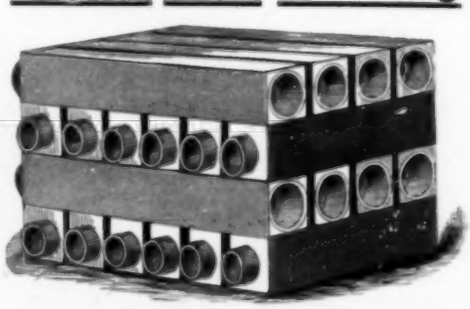
WRITE FOR BOOKLET

Anti-Hydro Waterproofing Co.

HOME OFFICE: Newark, N. J.
NEW YORK OFFICE: Singer Building

Wood Pipe Square or Round

Highly Acid Resisting



Extensively used for Acid Drains

For fifty-three years Wyckoff Wood Pipe has been made by us, and in that time it has been widely used and has given excellent service in conveying acid liquors; tan liquors, hot and cold; and for conveying mine water.

The wood is not injured by the acids and fumes of many fluids which act destructively on metal piping, or by the sulphur and other impurities of mine water. Wyckoff Wood Pipe does not rust, contaminate fluids, taint water, or burst if frozen. It is cheap, durable, economical, quickly and cheaply laid, connections are easily made, and is protected with a double coating of Hydrolene from inside and outside attack.

Our customers have written a book of references. Send for it.

A. WYCKOFF & SON CO.
Elmira, N. Y.

R.I.W.
REMEMBER IT'S WATERPROOF
REG. U.S. PAT. OFF.

MEANS
PROTECTION
PRESERVATION
PERMANENCE

R.I.W. REMEMBER IT'S WATERPROOF
HOSPITAL & LABORATORY ENAMEL

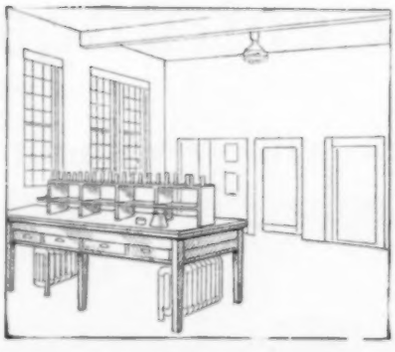
—a white coating resistant to acid-fumes, gases and chemicals.

This is an enamel especially adapted for laboratories, milk-stations, engine-rooms, hospitals, etc.

Besides resisting the action of sulphuretted hydrogen, acid-fumes, gases and chemicals, it stands heat, is waterproof and may be washed with any neutral soap.

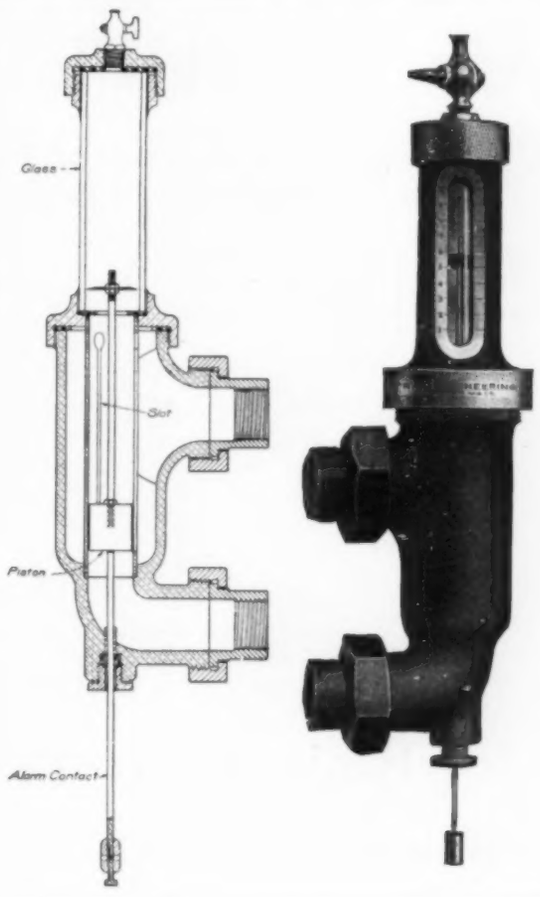
It positively will not turn color. A three-coat enamel that may be had in dull finish, matt finish or high-gloss.

Write our Dept. T for copy of H. & L. Enamel Booklet



Toch Brothers

Technical and Scientific Paint Makers since 1848
320 Fifth Avenue, New York
Works: NewYork; London, Eng.; Toronto, Can.



How many gallons per minute? Put it up to the

Vaughan Flow Meter

It is of the greatest advantage to KNOW HOW much liquid is being fed to a piece of apparatus. No one has greater need for accuracy in this respect than the manufacturer of chemical and allied products.

A piston in the Vaughan rises higher and higher as the flow of liquid increases. A gauge at the top tells you *exactly* what is taking place, and an electric contact at the bottom will warn you by lamp or bell should the liquid fall below a fixed minimum.

Valuable in a large number of applications.

Write for interesting description of the simple but effective device.

We also manufacture "Spraco" Spray Nozzles in all sizes. Give a dense, finely-divided spray with ordinary pressures. For cooling liquids and gases in the chemical industries; washing and humidifying air; cooling air for steam turbine generators, etc. Used by hundreds of concerns, large and small for cooling condensing water, jacket water, etc.

Spray Engineering Company
Boston, Mass.

Chemical Plant and Apparatus

Special Apparatus of the most improved design for all Chemicals, Drugs and Materials, including:—

Stills

Continuous and Periodic

for Acetone, Alcohols, Aldehydes, Benzol, Toluol, Essential Oils, Ethers, Acetic Acid, Phenol, Oils, Spirits, Salicylic Acid, Turpentine, and Derivatives.

Evaporators

Patented "MULTIPLEX" Film Evaporators, Multiple Effect Apparatus, Vacuum Pans, Pressure Pans, Dryers, etc., for Sugar, Glue, Tannin Extract, Malt Extract, Milk, Glycerine, Caustic Soda, Acetates, etc.

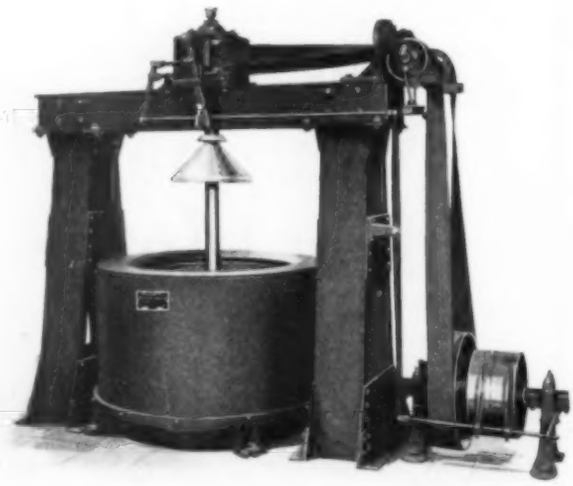
Complete Plants (Proved in operation)

Wood Distillation, Acetic Acid, Acetone, Tannin Extract, Sugar, Distilleries, Coal Tar Products, Aniline Dyes, Glycerine, Fat Splitting, Synthetic Phenol, T-N-T, Picric Acid, Ether, Solvent Recovery, Etc.

Blair, Campbell & McLean, Ltd.

Glasgow, Scotland

Established 1838 Cables: "BLAZON, GLASGOW"



Tolhurst Suspended Centrifugal

made with or without bottom discharge

Tolhurst Machine Works

Troy, New York

Southern Agent:
FRED H. WHITE
Realty Bldg., Charlotte, N. C.

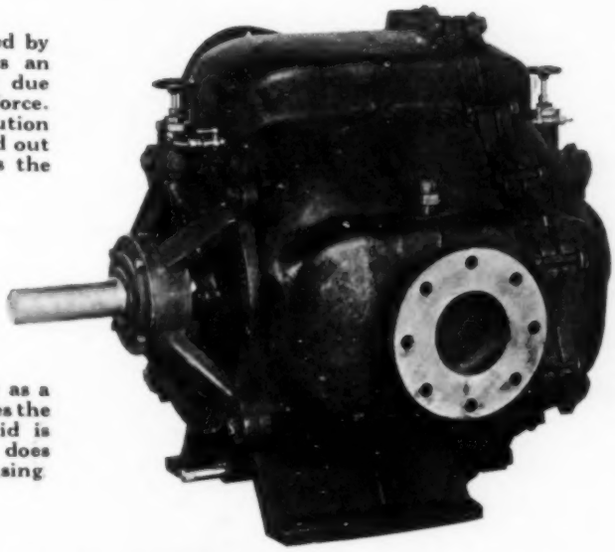
New York Representative:
FRED A. TOLHURST
106 Central Park West, New York City

Western Representative:
JOHN S. GAGE
Hartford Bldg., Chicago, Ill.

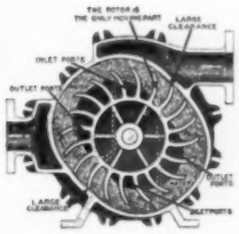
For Compressing Chlorine Gas

The Nash Hydro Turbine

The acid revolved by a rotor follows an elliptical casing due to centrifugal force. Twice in a revolution the acid is forced out of and re-enters the rotor.



The pump is supplied with ball bearings located outside of the casing. The packing in the stuffing boxes does not come in contact with the acid.



The acid acting as a piston compresses the air. As the acid is concentrated it does not attack the casing

NASH ENGINEERING CO., South Norwalk, Conn., U. S. A.

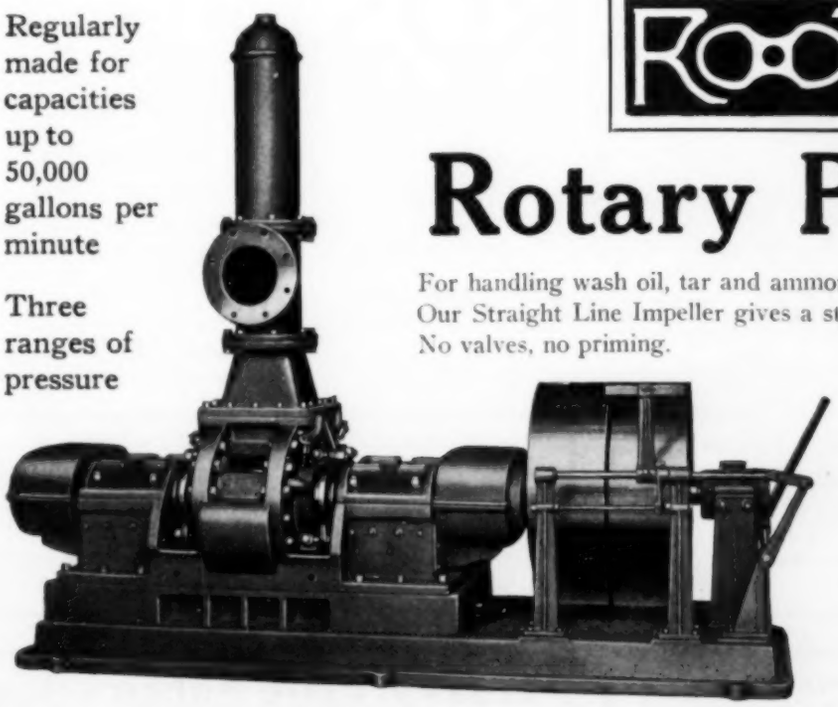
ROOTS

Rotary Pumps

For handling wash oil, tar and ammoniacal liquor.
Our Straight Line Impeller gives a steady, positive, quiet flow.
No valves, no priming.

Regularly made for capacities up to 50,000 gallons per minute

Three ranges of pressure



Write for Catalog 55

P. H. & F. M. Roots Company

NEW YORK
120 Liberty Street

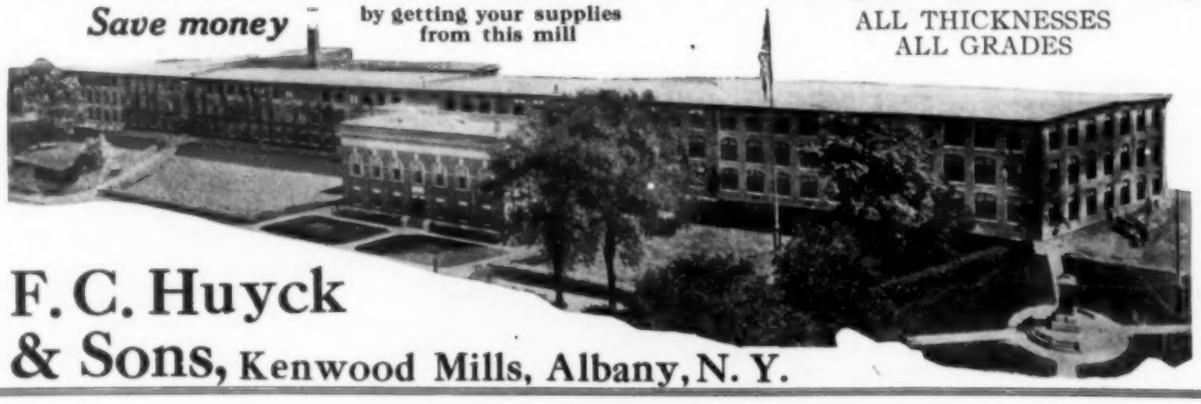
CONNERSVILLE, IND.

CHICAGO
1245 Marquette Bldg.

To American Users of Filter Cloths and Paper Makers' Felts

Save money by getting your supplies from this mill

ALL THICKNESSES
ALL GRADES

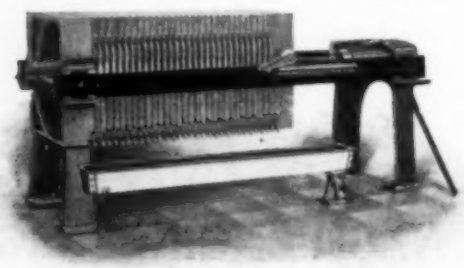


F. C. Huyck & Sons, Kenwood Mills, Albany, N. Y.

THE "JOHNSON" FILTER PRESS

Backed by 38 years' experience

Over 15,000 in use



JOHN JOHNSON COMPANY
37th Street and Second Avenue, Brooklyn, New York

Porous silica **FILTROS** plates are

giving satisfactory results when used for the following:

Filtration
of acids, organic and inorganic, and the neutral solutions.

Aeration and Agitation
in the cyanide process of ore treatment. For diffusing gases and for diffusing air in the activated sludge process of sewage treatment.

Flotation
of ores in the hydro-metallurgical process of treatment.

GENERAL FILTRATION CO., Inc.
Cutler Building Rochester, N. Y.

DESIGN
CONSTRUCTION
ERECTION

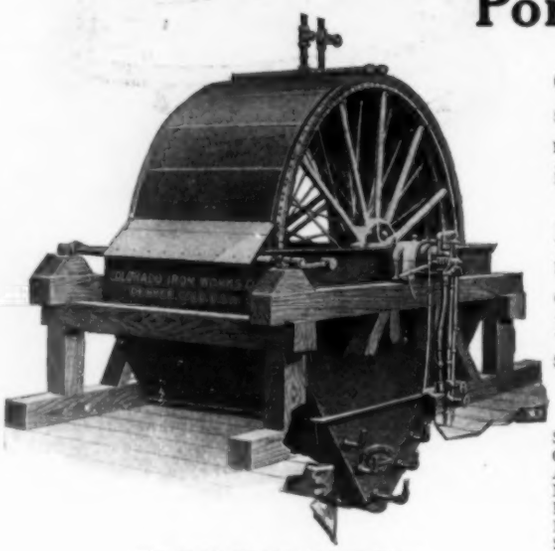
Chemical and Industrial Equipment
Rapid Delivery—Fine Workmanship
Henry E. Jacoby
Contracting Engineer
95-97 Liberty St. New York

DRAEGER RESCUE APPARATUS
Draeger apparatus including the Pulmotor is used exclusively by all the leading chemical and manufacturing corporations throughout the country.
Write for details on our new Type B Pulmotor—the only hand operated resuscitation device physiologically correct, safe and efficient.
The Draeger Oxygen Apparatus Co., 413 First Ave., Pittsburgh, Pa.
Makers of Complete Mine Rescue Apparatus.
Agents for Wolf Safety Lamp Co. of America.

PURE DISTILLED WATER
for all purposes obtained with
REILLY MULTICOIL EVAPORATORS
Write for Particulars.
THE GRISCOM-RUSSELL CO.
2150 West St. Bldg., New York

Heavy Plate Fabrication
Dryers, Digesters, Cookers, Chemical Tanks, Welded Vessels, Galvanizing Kettles, Autoclaves, Mixers, Incinerators, Retorts, etc.
Manitowoc Engineering Works
MANITOWOC, WISCONSIN

Every Mill Operator Should get the Full Facts about the Portland Continuous Filter



The Portland Continuous Filter

No royalty to pay, no anxiety about patent litigation. We guarantee that the Portland Continuous Filter does not infringe any legal rights of other patent owners.

Get them to see if he can utilize the Portland to reduce shipping costs and waste in handling concentrates, as so many others have done. Get them to learn of the marked individual superiorities of this notable Continuous Filter.

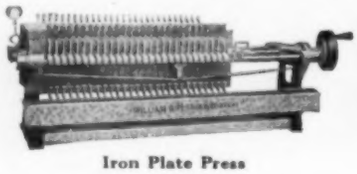
Filtration with a Portland Continuous Filter is a subject rich in real opportunities for real economies in nearly every mill. **Do not fail to send for a copy** of the new Bulletin, 28-B. You will find it interesting and instructive.

Some of the Users of Portland Continuous Filters

Smuggler-Union Mining Co., Utah Copper Co., Ray Consolidated Copper Co., Chino Copper Co., Mogul Mining Co., Portland Gold Mining Co., Cons. Arizona Smelting Co., U. S. Smelting, Ref. & Mining Co., Butte & Superior Mining Co., Barnes-King Development Co., Silver King Coalition Mines Co., Empire Copper Co., Cornucopia Mines Co., Baker Mines Co., Amalgamated Pioche M. & S. Corpn., Nevada Cons. Copper Co., American Zinc, Lead & Smelting Co.

Colorado Iron Works Company

Established 1860 Denver, Colo.



Iron Plate Press

FILTER PRESSES

We make all sizes and styles from 12 inch to 40 inch. For all liquids which require filtering.

Acids, Chemicals, Colors, Oils, Paints, Varnish, Glue, Glucose, Starch, Lard, Syrup, Yeast, Glycerine, Liquid Soap, Lyes, Tallow, etc.

WILLIAM R. PERRIN & COMPANY

Old Colony Building CHICAGO, ILL.

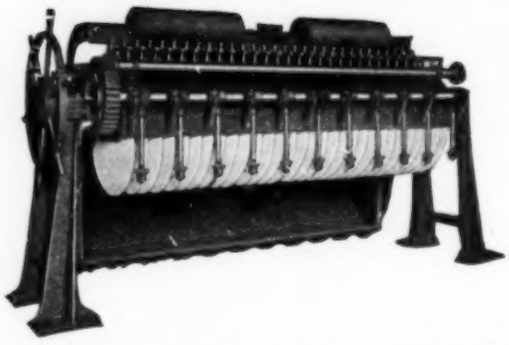
FILTER PRESSES

We manufacture a complete line of filter presses for use in chemical, electro-chemical works and the glue, ink, paint, oil, battery, carbon, graphite, paper, powder, rubber, salt, soap, sugar and dye and color industries.

A Perfect Press for General Work
Made in four sizes—18 in., 24 in., 30 in., 36 in. square. Recessed Plates. Center Feed. Open Delivery.

Special presses built with wood plates and frames, also of bronze and other acid and alkali-resisting metals.

The Allbright-Nell Co.
Manufacturers
Chicago, Ill.



A Shorter Pay Roll and a Longer Profit

This condition, which is the prime object of employing efficiency experts, is brought to realization to users of

Sweetland Self-Dumping Filters

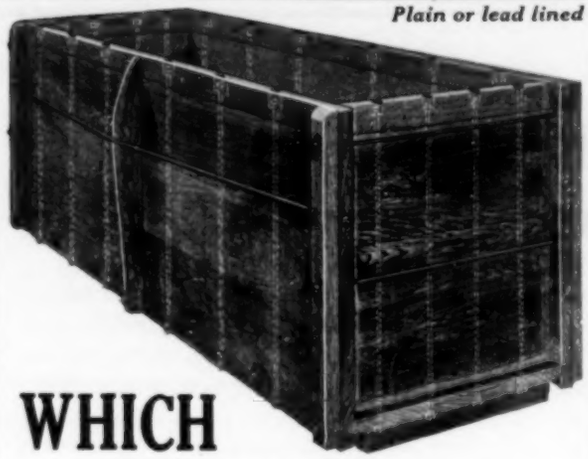
Less Machinery and less labor is required. The high washing efficiency, quick dry discharge and high economy account for the orders received from men who *know* filters.

Have you received your copy of Catalog No. 12?

Sweetland Filter Press Co., Inc.

Sperry Building, Brooklyn

Plain or lead lined



WHICH

DO YOU CONSIDER FIRST

SERVICE or COST?

HAUSER-STANDER TANKS ARE BUILT FOR SERVICE

WOODEN TANKS FOR EVERY PURPOSE
ANY SHAPE ANY SIZE

The Hauser-Stander Tank Co.
Cincinnati, Ohio
WE WIN WITH QUALITY

COPPER APPARATUS
Backed by Experience

Thirty-five years' experience is built into every piece of copper, brass, iron and sheet metal apparatus that bears our name. Direct supervision by experts in our own manufacturing plant insures quality of materials and workmanship in every detail.

Our line includes Ovens, Storage Tanks, Copper Coils, Kettles, Stills, Vacuum Pans and Condensers. Write for Catalog.

We also manufacture
Cold Process Gasoline Plants

Detroit Heating & Lighting Co.
(Est. 1868) DETROIT, MICH.

Evaporating Machinery

As Chemical Process Engineers we specialize in Evaporation, and are the largest builders of Evaporating Machinery. Make no move until you consult us. Profit by our eighty years' experience.

Results Guaranteed

in Recovery of Trade Wastes, Distillation, the manufacture of Caustic Soda, Caustic Potash, Bleach, etc.

Chemical Apparatus designed and furnished for all purposes. We superintend erection, instruct operators and guarantee correct working.

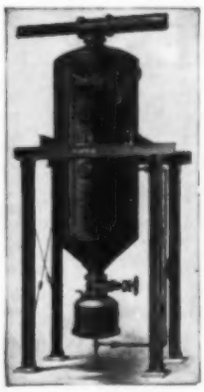
Ernest Scott & Company
Engineers
Business founded in 1834
Fall River, Mass.

WHEELER
Evaporators and Dryers

The experience of the Wheeler Condenser & Engineering Co. in the design and construction of vacuum pans, multiple effects, evaporators, dryers and kindred machinery dates back to the founding of the company, a quarter of a century ago.

Send for our new Catalog 105-A, describing Wheeler products for chemical plants.

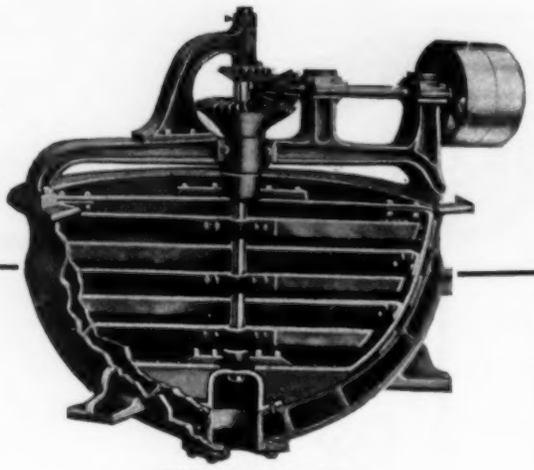
Wheeler Condenser & Engineering Co.
Carteret New Jersey



Robert S. Redfield
Engineer and Manufacturer

Evaporators
Filter Presses
Dryers, and a general line of
By-Product Machinery
for the Chemical Industries.

327 S. LaSalle St., Chicago



STYLE D AGITATOR
Bridge Type, 100–800 Gallon Capacity

Selected from 248 types and sizes of

DOPP Seamless Apparatus

to give a hint of what you get in the way of design, construction and service when you buy a Kettle, Mixer or Vacuum Pan from us.

First, you get trouble-free operation and ease of emptying or cleaning because of the smooth *cast* (not machined) inner surface.

Second, you get one-piece castings, free from vulnerable bolts or rivets—free from the *possibility* of leaks.

Third, you get choice of our many styles, or special construction if you want it.

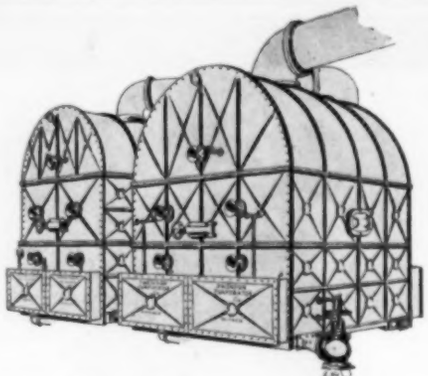
Fourth, you get the benefit of our 58 years' experience and our *everlasting* guarantee against defective material or workmanship.

Fifth, you *should* get Catalog V, Section 1.

Sowers Manufacturing Co.

1302 Niagara St. BUFFALO, N. Y.
39 Cortlandt St. NEW YORK CITY

ADOPT THE DOPP



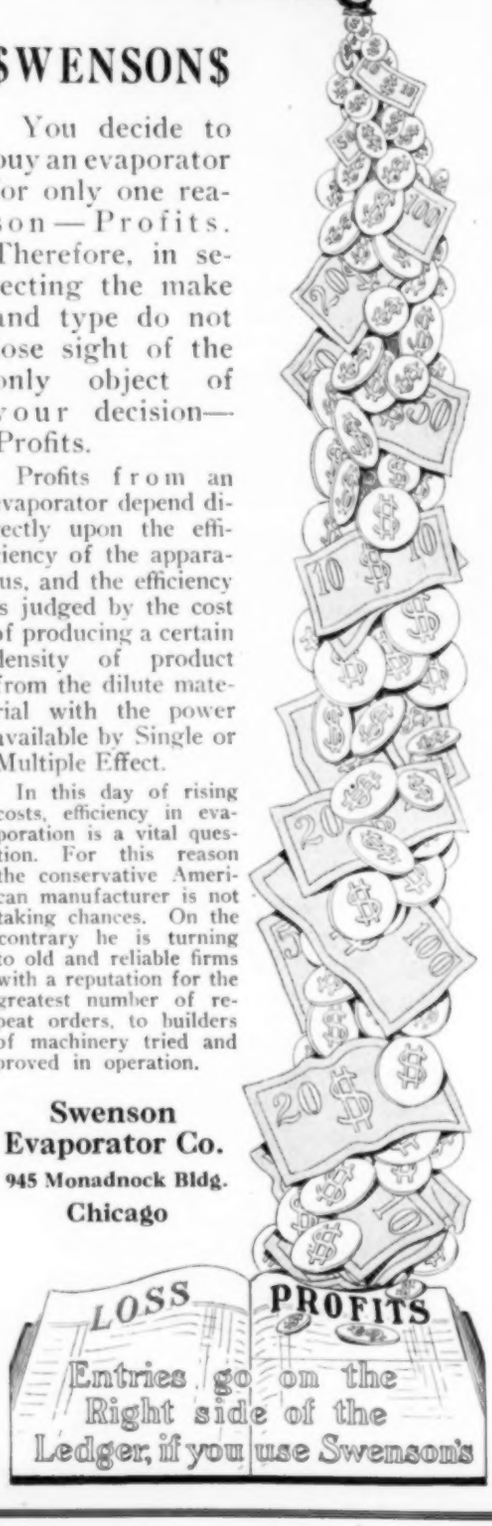
$WENSON$

You decide to buy an evaporator for only one reason—Profits. Therefore, in selecting the make and type do not lose sight of the only object of your decision—Profits.

Profits from an evaporator depend directly upon the efficiency of the apparatus, and the efficiency is judged by the cost of producing a certain density of product from the dilute material with the power available by Single or Multiple Effect.

In this day of rising costs, efficiency in evaporation is a vital question. For this reason the conservative American manufacturer is not taking chances. On the contrary he is turning to old and reliable firms with a reputation for the greatest number of repeat orders, to builders of machinery tried and proved in operation.

Swenson Evaporator Co.
945 Monadnock Bldg.
Chicago



One-piece, Enameled, Jacketed Mixing Tank. Agitator is Steel, Glass Enameled. Capacities from 50 to thousands of gallons.

PFAUDLER

GLASS ENAMELED STEEL TANKS AND APPARATUS

Mixing Tanks **Vacuum Pans**
Autoclaves **Nitrators**
Kettles **Stills**
Storage Tanks **Car Tanks**
and many other types

strongly built of steel and lined with Glass Enamels which, being exceptionally homogeneous and very resistive, form effectual barriers against severe corrosive action.

Would it not be worth while to investigate the adaptability of these responsibly backed products to *your* needs? Write to us while the subject is fresh in your mind.

Have you received Bulletin C-3?

THE PFAUDLER CO.
ROCHESTER, N. Y.

New York 110 West 40th St.
Chicago 1001 Schiller Bldg.
San Francisco, 512 Sharon Bldg.

Tested for Toughness—

See the result of a U. S. Government Bending Test—Machined Monel Metal bar, showing toughness and ductility without fracture. Bar had been previously machined to bring out any slight defects that might develop on the surface due to stretching of remotest fibres.

Monel Metal

Monel Metal is not only tough by physical tests but tough and wear-resisting under exposure to acid fumes, gases atmospheric conditions and other corroding influences. Monel metal endures where ordinary metals give out. Write for particulars regarding your problems.

Ask to have the "Supplee-Biddle Bulletin" sent you every month.

Supplee-Biddle Hardware Co.
Manufacturers of Monel Metal

512 Commerce St.
Philadelphia

343 Hudson Terminal Bldg.
New York

BRANCH OFFICES:
London Montreal Stockholm Buffalo

CHEMICAL EQUIPMENT
OF METAL

One Customer Says

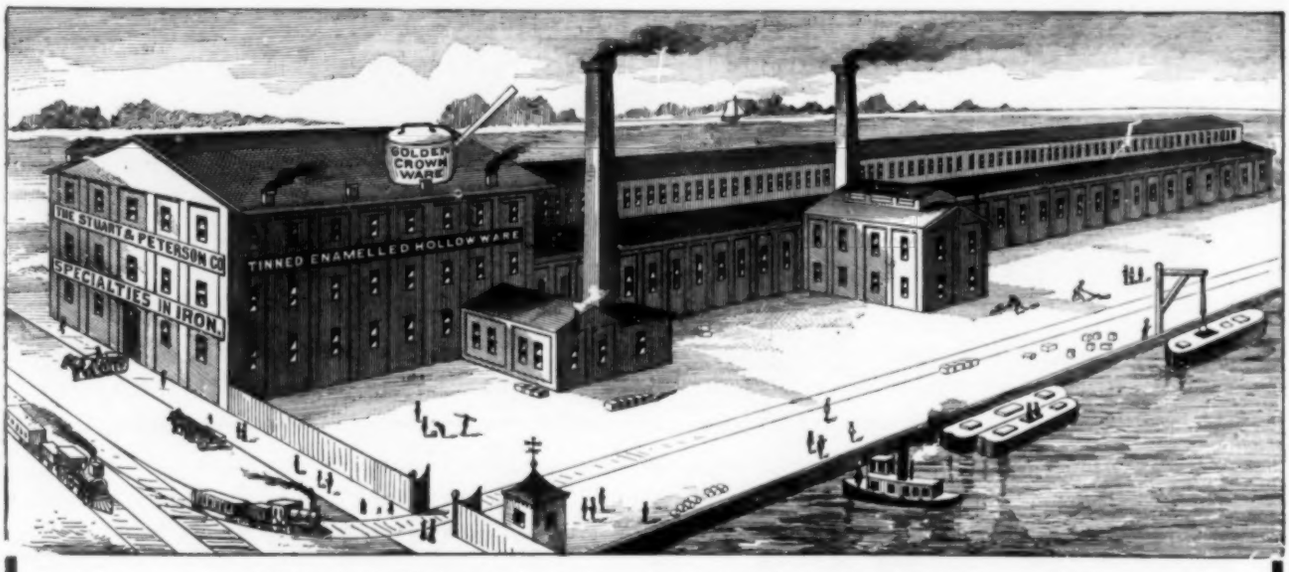
"Every piece of Apparatus you have designed and built for us has outlasted any built by your competitors."

Which makes it unanimous.

STEVENS BROTHERS

Engineers — Contractors

Room 929 149 Broadway New York



The success of Stuart & Peterson Apparatus is indicated by the fact that our establishment is pre-eminent in both age and size. Seventy-six years ago we started this business by making a line of Chemical Apparatus and our success is due to its quality.

The Stuart & Peterson Co., NEW YORK OFFICE: 95 Liberty St.
PLANT AND GENERAL OFFICES: Burlington, N. J.

Vacuum Stills
Steam Jacketed Kettles
Evaporating Dishes
Storage Cans
Tanks
Nitrating Stills
Autoclaves
Retorts
Annular Kettles
Sterilizers

Stuart & Peterson Apparatus

Glass for Purity — Steel for Strength

Both are combined, and the glass is virtually a part of the steel, in

ELYRIA Glass Enameled Products

The ideal condition in distilling, evaporating, heating and storage is **purity, plus strength** which you find in ELYRIA Glass Enameled Products. Lining and steel are **fused** together at 2000° F. No scaling, crazing or cracking.

Seamless One-Piece

The tank seams are welded by the atogenous process, presenting a uniform surface, with no bolted or packed joints.

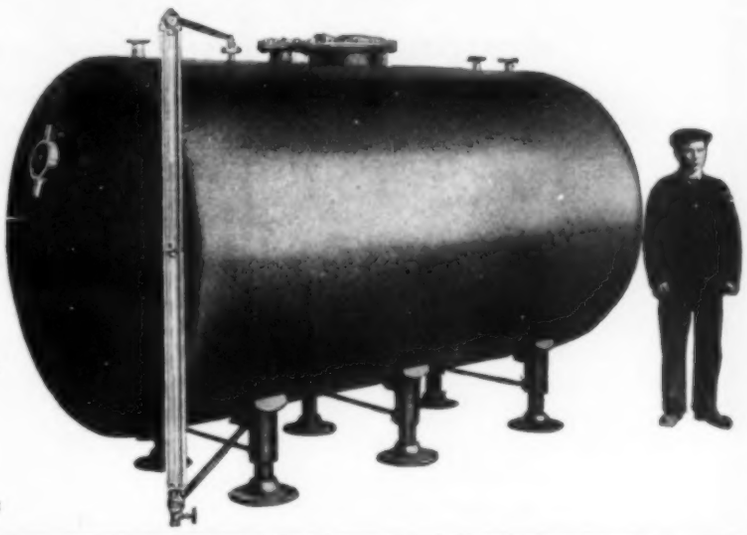
The illustration shows an ELYRIA Tank which can be furnished up to 4,000 gallons capacity.

We can furnish Storage Tanks, Stills, Vacuum Pans, Autoclaves, Close Jacketed Tanks, also Agitators or Mixers of any type, Condensers, Preheaters, Coolers, etc.

Send for Catalog

The Elyria Enameled Products Co.
Elyria, Ohio

New York, 50 Church Street
Pittsburgh, 1237 Oliver Bldg.
Chicago, 1033 West Lake Street
San Francisco, 16 California Street



SEAMLESS STEEL CONTAINERS AND TANKS
BOWLS—BUCKETS—CANS AND SPECIALS

POTS

PANS

Janney-Steinmetz Co.
Philadelphia and New York

GASOLINE RESERVOIRS AND PRESSURE TANKS

Above is shown the tops of two Sperry Autoclaves, built for use in the manufacture of dyes. These Autoclaves were steam jacketed, agitated and provided with two 12" hand holes. The bottom was drained by a special 3" valve jacketed by steam

AUTOCLAVES

We are in a position to make cast-iron vessels of various shapes to suit your requirements. Tell us your needs and let us submit figures.

D. R. SPERRY & CO., Batavia, Ill.

Manufacturers of

THE SPERRY FILTER PRESS
THE BEST FILTER PRESS MADE

CONTAINERS AND CANS

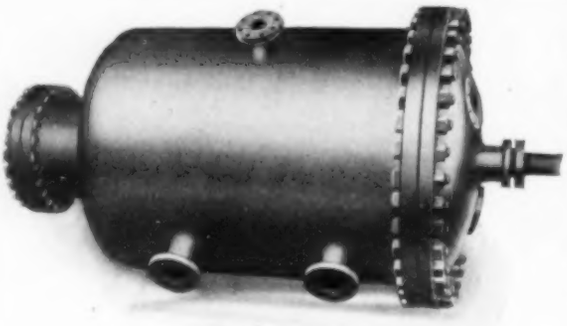
open or closed, made in any shape or dimensions and of any thickness of material desired. These are made of iron, copper and other metals, and are used by ink, rubber, iron fittings, powder, shot, celluloid, gun cotton, ammunition and other manufacturers.

If you will tell us what you want it will be our pleasure to fill your order.

CHEMICAL MACHINERY
METALLURGICAL APPARATUS

L. O. KOVEN & BROTHER

Main Office: 154 Ogden Avenue, Jersey City, N. J.
New York Office: 50 Cliff Street



Forge and Hammer Welded Still

The Highest Economy

results from the use of

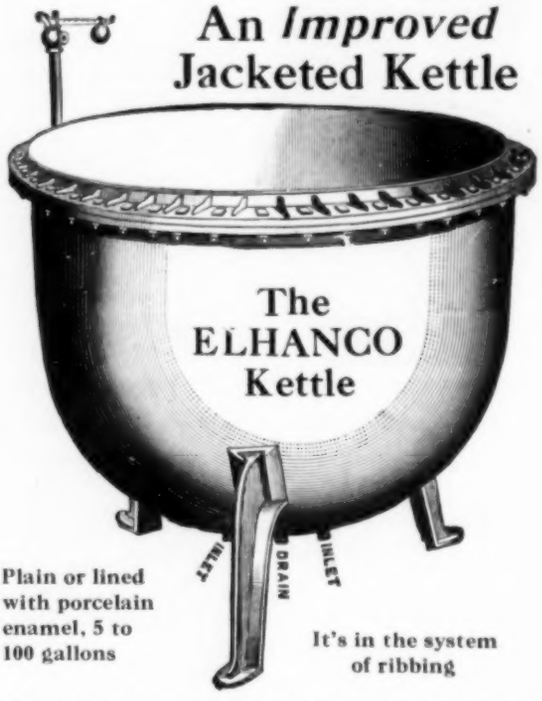
Kellogg Forge and Hammer Welded Apparatus

Autoclaves, digesters, stills, cyanide pots, annealing kettles, and high-pressure containers of all descriptions offer maximum advantages when made by this process. We will send our representative on request.

The M. W. Kellogg Co.

90 West Street, New York

An *Improved* Jacketed Kettle



Plain or lined with porcelain enamel, 5 to 100 gallons

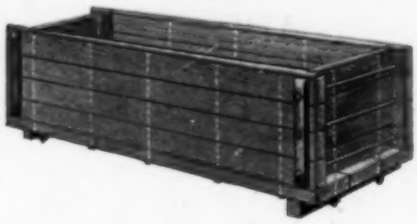
It's in the system of ribbing

They heat quicker and give maximum resistance to high steam pressure. Safe and profitable to operate. Equipped with power agitator if desired. Send for catalog, which also shows our line of Evaporating Dishes, Caldrons and Sugar Pans.

Edward L. Hand & Company

722 Arch Street, Philadelphia, Pa.

Made To Order



All Shapes and Sizes

Kalamazoo Tanks

We will build you any kind of a tank you want and *make* it fit *your* requirements.

Give them a test and they will demonstrate their high quality in material, workmanship and long life under hard and exacting conditions.

KALAMAZOO TANK & SILO CO.
MICHIGAN

Chemical Stoneware

Our enormous plant has been built on QUALITY

and nowhere is quality so necessary as in Acid- and Alkali-proof Chemical Stoneware. We make everything in this line as regards standard designs and bricks, and produce special designs according to requirements of customers. No order too large—none too small.

The U. S. Stoneware Co.
Established 1865 Akron, Ohio, U. S. A.

8591

The Ultimate Economy lies in
Genuine Imported German Chemical Stoneware

HIGH GRADE EUROPEAN PORCELAIN WARE for chemical and electrochemical plants, laboratories, electrolytic refineries, etc.

ENAMELED CAST IRON APPARATUS (German Ware), acid-proof, durable, sticks firmly to metal, resists high temperatures. Made up to largest sizes.

HARD PORCELAIN BALL MILLS (German Ware), hand or power drive, for wet or dry grinding of quartz, feldspar clays, white lead, chemicals, drugs, spices or other materials.

ACID PROOF CEMENT, cement-mortar, not affected by cold or hot acid or lye—for lining vats, receivers, for tightening pipes, for acid towers—wherever acid is handled. Eliminates necessity for lead.

DRY VACUUM PUMPS for the manufacture of incandescent lamps, gunpowder, explosives, etc. For exhausting air or gases through liquids. For chemical and sugar work and for use with impregnating machinery.

IMPORTED ACID BRICK made of Obsidianite (English Product), a perfectly vitreous non-absorbent material—impervious to acids; also fireproof. We furnish the complete stoneware outfit for the manufacture of Nitric and Muriatic Acid. Denitration plants for mixed acids, plants for regeneration of nitric acid and also single apparatus for any purpose.

J. W. Sittig, Importer, Temple Court Bldg., New York

Tank Troubles

and WORRIES are not chronic with a TANK that is well made and designed to accomplish specific results.

The Engineering, Designing, Manufacturing and Erection of CORCORAN Tanks is so carefully done that troubles and worries are practically eliminated. If you want a Satisfactory TANK, you may obtain desired information from

A. J. CORCORAN, Inc.
Established 1865 9 JOHN ST., NEW YORK CITY

EAGLE TANKS

We build everything needed by the Chemical industries in the line of tanks, vats, generators, sulphur towers, etc. Don't buy before investigating our prices.

EAGLE TANK CO. 2442 N. Crawford Ave. CHICAGO, ILL.

WOOD TANKS

of every kind—Fir, Cypress, Pine, Redwood

Send us your specifications

U. S. WIND ENGINE & PUMP CO.
15 WATER STREET,
BATAVIA, ILLINOIS

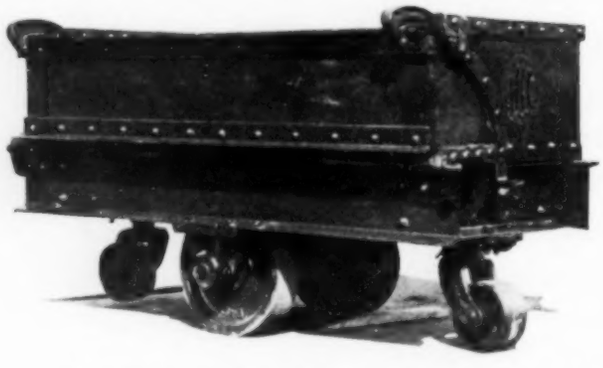
It's certainly reassuring to know where you can get complete plants for the manufacture of chemicals these busy days!

GAW

Have you gotten OUR figures?

German-American Stoneware Works

Office, 50 Church Street, New York City
Factory, Keasbey, N. J.



Special Pig Iron Charging Car of Unusual Construction

Provision to withstand the considerable abuses of this class of service was made by building the car body of ¼-in. and 5/16-in. plate, with heavy channel iron underframe. Sides and doors were braced by angles, and heavy wheels and bearings supply the necessary strength to meet the severe requirements of foundry work without harmful deterioration. Swiveling wheels at the ends permit the car to be turned in any direction or pushed in any way. Capacity of this car is about 2500 lb.

Cars of this type, but of lighter construction, are used in power plants for handling coal, the fuel being shoveled directly from the cars into the fire-box, these cars being known as coal-charging cars.

Any number of variations are possible with this type of car, including dumping gear, both sides let down, both ends let down, etc.

Put Your Car Problems Up to Us

We can usually solve them with standard styles or their adaptations, thus saving you the expense of strictly special designs. For twenty-five years we have been adding to our stock patterns, and the enormous variety of car needs we have filled during that time are available to you today. Write our Engineering Department.

Easton Car & Construction Co.
Fourth and Northampton Sts., Easton, Pa.
New York Boston Detroit Chicago Milwaukee

Easton Car & Construction Co.
Easton, Pa.

Send me a copy of your new industrial Catalog No. 5081.

Name .....

Address .....

.....

Specify Through Your Dealer

Trade GUERNSEY Mark.

Guernsey Laboratory Porcelain

VITRIFIED — For Chemical and Analytical Work

POROUS—For Electrolytic and Filtration Purposes

Constitutes an always safe and sane purchase

Write for our literature on chemical porcelainware. A trial is our best demonstration of the economy of Guernseyware.

The Guernsey Earthenware Co.

First American Manufacturers Chemical Laboratory Porcelain

104 East End St. Cambridge, Ohio

DAIGGER

Chicago, Ill.

LABORATORY SUPPLIES AND CHEMICALS.

We can make immediate shipment from our complete stock

A. DAIGGER & CO.

54 W. Kinzie St. CHICAGO

Quality Glassware

Libbey

stands for insolubility, low coefficient of expansion, uniformity and strength—now the favorite among leading chemists.

Send a Trial Order Today.

Distributed only by

Eberbach & Son Co., Inc.

Established 1843

E&SCo

Ann Arbor, Mich.

PALO is the guarantee for service and efficiency.

Our immense stock of Laboratory Supplies and Chemicals enables us to fill your orders promptly.

Our workshops and Glass-blowing Department will take care of special work.

PALO COMPANY

Laboratory Supplies and Chemicals

90-94 Maiden Lane, New York

Laboratory Apparatus Supplies and Chemicals

Immediate shipment of all Laboratory supplies.

Schaar & Co.

1025 S. State St. Chicago

"OHIO" PORCELAIN

is perfectly tempered and is giving universal satisfaction. *"Solno" Glassware* has a reputation for great resistance. We carry a full line of both; also laboratory supplies.

Write for samples and prices.

THE LABORATORY SUPPLY CO.

236 N. 3rd Street, Columbus, Ohio

Maurice A. Knight

Manufacturer of

Acid-Proof Chemical Stoneware

East Akron, Ohio

VITREOSIL

Apparatus for the Chemical Industries

PURE FUSED SILICA
VITREOSIL
REGD TRADE MARK
THE THERMAL SYNDICATE, LTD.
WALLSEND-ON-TYNE

WE have just issued a descriptive booklet dealing with tried and proven applications of Vitreosil in the manufacture of Sulphuric, Nitric and Hydrochloric Acids, the denitration of Waste Mixed Acids, etc. You probably use some Vitreosil equipment in your Sulphuric Acid plant—this booklet will suggest possibilities of cutting out corrosion or high temperature plant failures in other departments of your factory.

The use of Vitreosil is not restricted to Sulphuric Acid manufacture. It is always of service where corrosive conditions, or the necessity of absolute purity in the finished product, exist.

The Thermal Syndicate, Ltd.
Chemists Building
50 E. 41st St., New York City

Thermometers Hydrometers Laboratory Glassware Chemical and Physical Apparatus

Everything listed in our 150-page Catalog is carried in stock or supplied promptly

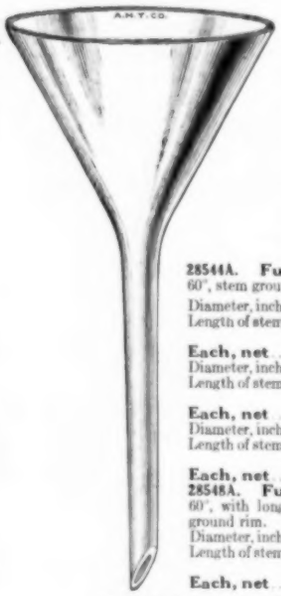
The completeness of our line is readily apparent. Articles not listed we can import or make to order, as we are manufacturers.

Years of intimate contact with customers has given us the experience necessary to satisfy the most exacting demands for Laboratory Apparatus. Our stock has been selected for *reliability*.

Send for the catalog.

Griebel Instrument Co.
Manufacturers
Carbondale, Pa.

FUNNELS



These Funnels are made in the U. S. and are of distinctly better workmanship and appearance, and possess greater accuracy of 60° angle than the usual imported article.

We have had great difficulty in securing a sufficient quantify for daily requirements, but now have accumulated enough stock to justify our offering prompt shipment on orders as received.

28544A. Funnels, Glass, with an exact angle of 60°, stem ground to point and with ground rim.

Diameter, inches	1	1⅝	2	2½	3
Length of stem, inches	1¾	1¾	2¼	2½	3¼
Each, net	.20	.20	.22	.25	.28
Diameter, inches	3½	4	5	6	7
Length of stem, inches	3½	4½	5	5½	6
Each, net	.30	.32	.69	.65	.80
Diameter, inches		8	9	10	12
Length of stem, inches		6	7½	8¾	8¾
Each, net			.95	1.50	1.90 2.45

28548A. Funnels, Glass, with an exact angle of 60°, with long thin stems ground to point, and with ground rim.

Diameter, inches	1	1⅝	2	2½	3	3½	
Length of stem, inches	3	3	4	4	4	4	
Each, net	.22	.22	.24	.25	.28	.30	

The above prices are net in any quantity and are subject to change without notice.

ARTHUR H. THOMAS CO.
IMPORTERS—DEALERS—EXPORTERS
LABORATORY APPARATUS AND REAGENTS
West Washington Square Philadelphia, Pa.

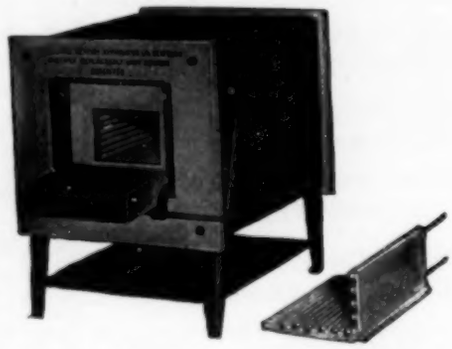
250 PERCENT INCREASE IN SALES IN 17 MONTHS

Definitely proves COMPLETE SATISFACTION to all users of

MULTIPLE REPLACEABLE UNIT ELECTRIC FURNACES

AND

MULTIPLE UNIT HOT PLATES



MUFFLE TYPE—HAS UNITS REVERSIBLE FOR OPEN GROOVE OR MUFFLE FACE ASSEMBLY

1914 MODELS
MADE
IN
MUFFLE,
TUBE
AND
CRUCIBLE
TYPES

COMBUSTION TUBE TYPE—GAVE 1576 HOURS IN LIFE TEST AT 1900° F.

CATALOGS UPON REQUEST

MULTIPLE UNIT FURNACES
CARRIED IN STOCK BY

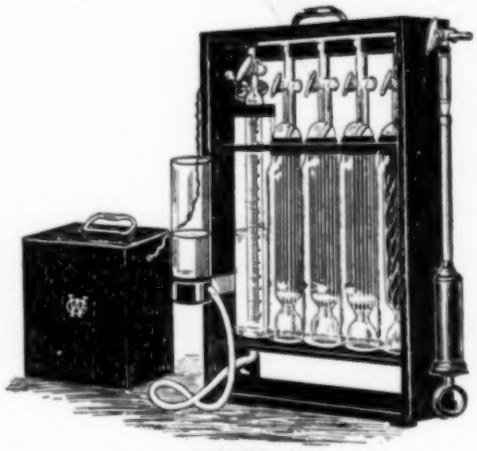
EIMER & AMEND, Pittsburg
E. H. SARGENT & CO., Chicago
EIMER & AMEND, New York
LYMANS, Ltd., Montreal
BRAUN-KNECHT-HEIMANN CO., San Francisco
EIMER & AMEND, Ottawa
THE BRAUN CORPORATION, Los Angeles
ARTHUR H. THOMAS CO., Philadelphia

ELECTRIC HEATING APPARATUS CO.
MULTIPLE UNIT FURNACES & HEATING APPLIANCES
GENERAL OFFICE & WORKS:
121-123 Sussex Ave., Newark, N. J.
Branch Office: 25 Church Street

ARE *YOU* IN THIS LIST?

Every power plant, burning fuel,
Every gas manufacturer,
Every engineering university,
Every metallurgical plant,
Every cement plant,
Every manufacturer of chemicals,
Every smelter,
Every iron and steel plant,
Every industrial laboratory,
Every sulphite mill, and many others,

Can Profitably Use a Williams Improved Gas Apparatus.



MODEL A.

For complete analysis of combustible gases. Especially adapted for determination of corrosive gases, chlorine, hydrochloric acid, sulphur oxides, etc.

Write for "Modern Methods and Apparatus for Industrial Gas Analysis." New enlarged edition just coming off the press. Contains tables and much useful information.

Williams Apparatus Co.
Park Place, Watertown, N. Y.
105

We specialize in

Pure Silver Pipe

RODS WIRE
SHEETS

Also many specialties for the chemical and allied industries. Your inquiries are solicited.

A. T. Wall Co.
162 Clifford St., Providence, R. I.

Hamburg Riveted Steel Tanks

For Air, Oil, Storage and Pressure
3-16 in. to 1-2 in. metal

Hamburg Boiler Works
Hamburg, Berks Co., Pa.

Asbestosteel is the combination of Asbestos Protected Metal and concrete and combines the advantages of sheet steel with the permanency of granite. Asbestos Protected Metal consists of Steel Sheets protected on all sides and edges by asphalt and pure long-fibre Asbestos Felt.

Ask for Bulletin 5415

Asbestos Protected Metal Co. First National Bank Building Pittsburgh.

Try Fry Resistance Glass

Judge it yourself.

Write to us for samples and we will send them prepaid.

This glass is now meeting approval of the best critics and it is right in all ways.

Distributed by Laboratory Supply Houses

H. C. Fry Glass Company
Rochester, Pa.

The Practical Laboratory Glass

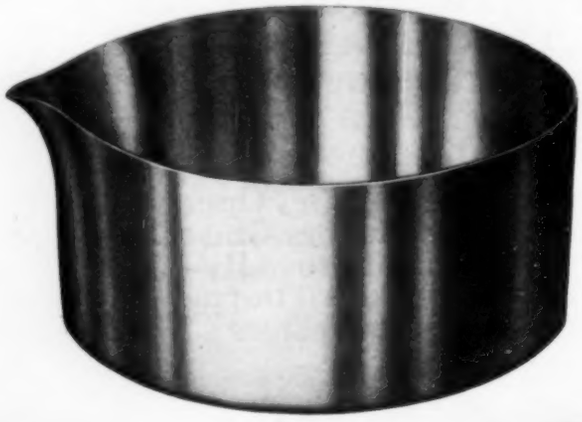
See Marking Shield TRADE MARK

Use your lead pencil for recording data

AMERICAN PLATINUM WORKS
225-231 New Jersey Railroad Avenue, Newark, N. J.

Hammered PLATINUM WARE of Every Description

Crucibles
Dishes
Boats
Electrodes
Spatulas
Cones
Triangles
Tweezers
Crucible Tongs



Scrap and Worn-out Ware, etc., Purchased or Taken in Exchange for New Ware, etc. Catalog Gladly Furnished Upon Request

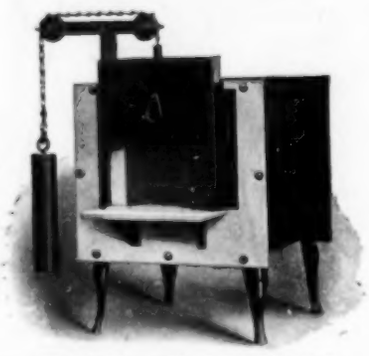
When you are in the market for Platinum Ware or Platinum Apparatus of any description of Superior Quality, write for our quotations.

New York Office: CHARLES ENGLEHARD, 30 Church St.

WELL BALANCED

HOSKINS Electric Furnaces

TRADE MARK REGISTERED



Muffle Type Hoskins Electric Furnace for Laboratory Use.

Not one feature in Hoskins Electric Furnaces is sacrificed to obtain greater value out of another. Every feature of design is evenly balanced about a central or ideal point representing 100% perfection. Result: A design from which the most accurate results can be obtained in the quickest possible time. No busy chemist can afford to be without a Hoskins Electric Furnace in his laboratory.

There's a Hoskins Electric Furnace for every laboratory use. Built in muffle, tube, and crucible designs. Bulletin sent on request.

Hoskins Manufacturing Company

457 Lawton Avenue, Detroit

Otis Bldg., CHICAGO
Oliver Bldg., PITTSBURGH
Grand Central Terminal, NEW YORK CITY
Tremont Bldg., BOSTON
Canadian Hoskins, Ltd., WALKERVILLE, ONT.

DEALERS!

Central Scientific Co., Chicago; Henry Heil Chemical Co., St. Louis; L. E. Knott Apparatus Co., Cambridge, Mass.; E. H. Sargent & Co., Chicago; A. H. Thomas Co., Philadelphia; Palo Company, New York; Scientific Materials Co., Pittsburgh; Bausch & Lomb Optical Co., Rochester.

H&M Thermometers

SIMPLICITY, RUGGEDNESS

Dependability, Accuracy Characterize H&M *Tycos* Thermometers, Recording and Indicating. Whatever the application, there's a *Tycos* Instrument for it. We make;

H&M Regulators, *Tycos* Mercury Operating Recording Thermometers, Glass Engraved Stem Thermometers, Hygrometers and Hydrometers Thermo-Electric and Radiation Pyrometers

A line complete and uninterrupted from fever thermometers to Fery Pyrometers. Every application met, and there are thousands.. Our installations for very critical and exacting manufacturers and to whom we can refer are to be found in every industrial point in the country.

Correspondence will have immediate and courteous attention

H&M Division

Taylor Instrument Companies

Rochester, N.Y.

Do you know why the

Steam Trap SARCO

is used by nearly all the big industrial concerns?

THIS IS WHY—

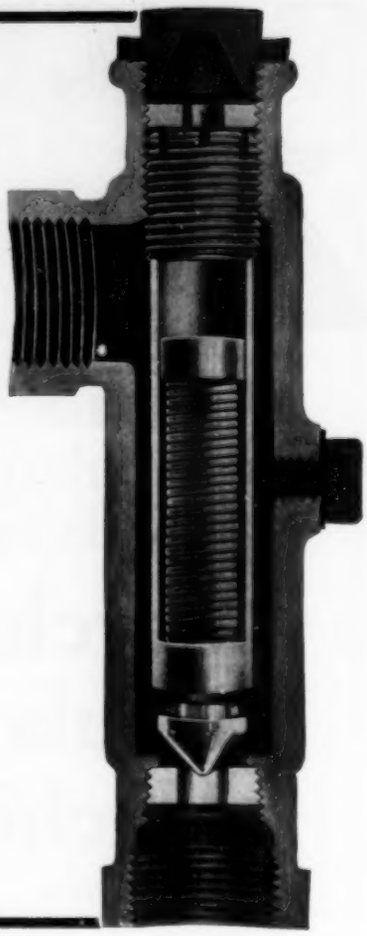
The Steam Trap SARCO is operated by the expansion of a liquid operating a spirally corrugated tube. There is no other steam trap made which uses liquid expansion and none can use this enormously powerful and reliable operating medium without using also the SARCO tube. Therefore of all thermostatic traps the SARCO claims to be the most positive—and it can be supplied not only for vacuum heating systems but for low pressure and high pressure steam up to 200 lbs. Do you know any other thermostatic trap used successfully for pressures above 50 lbs. or even as high?

Then as to installation. The SARCO fits in anywhere (1" size measures only 7½ inches); it needs no floor space or building up, but can be used as an elbow or bend, in the discharge. Although it does just the same work, it is not a heavy, cumbersome affair like a float or bucket trap. It is not a tank but a piece of live pipe.

Price—it is the cheapest trap on the market and owing to the enormous increase in sales and improved manufacturing facilities, we have not had to increase prices in three years.

Take a trap on thirty days trial and prove what you gain in first cost, cost of installation, and in steam saved.

Write for Bulletin F 1.

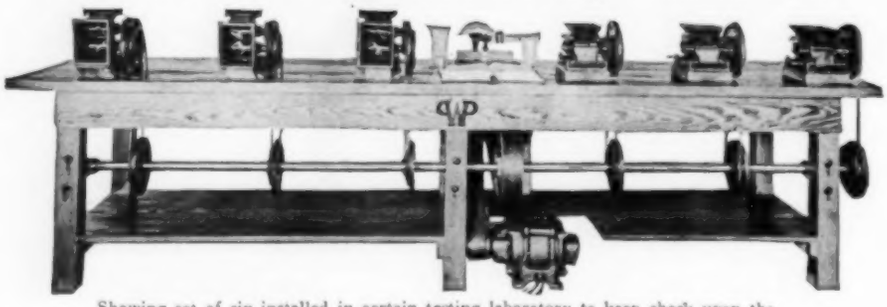


Sarco Company, Inc., Woolworth Bldg., New York

Drexel Building, Philadelphia; New Telegraph Building, Detroit; and Monadnock Block, Chicago

PEACOCK BROS., MONTREAL, CANADA

W. & P. Laboratory Mixers



Showing set of six installed in certain testing laboratory to keep check upon the uniformity and quality of materials purchased

These machines are extensively used for experimental work generally.
They are readily taken apart to clean.
Can be supplied for hand drive or power drive.
For factory use W. & P. Mixers are made in many standard sizes up to 3000 gals.

We also Manufacture

Vacuum Kneaders **Rapid Dissolvers and**
Filter Presses (high pressure) **Rubber Machinery**

Ask for literature.

Werner & Pfleiderer Company, Inc.

Factory and Main Office: Saginaw, Mich.

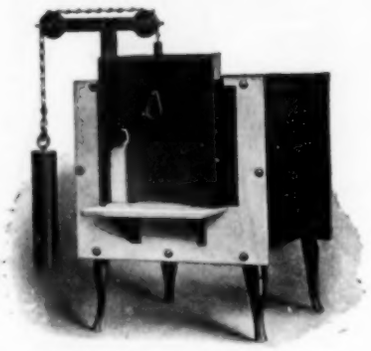
New York Office: 41 Park Row
Philadelphia Office: Drexel Bldg.
San Francisco Office: Pacific Bldg.

European Houses:
Cannstatt-Stuttgart, Paris, Moscow, Milan, Zurich, Hague, London, Berlin, Hamburg, Cologne, Frankfort, Vienna, Dresden, Peterborough

WELL BALANCED

HOSKINS Electric Furnaces

TRADE MARK REGISTERED



Muffle Type Hoskins Electric Furnace for Laboratory Use.

Not one feature in Hoskins Electric Furnaces is sacrificed to obtain greater value out of another. Every feature of design is evenly balanced about a central or ideal point representing 100% perfection. Result: A design from which the most accurate results can be obtained in the quickest possible time. No busy chemist can afford to be without a Hoskins Electric Furnace in his laboratory.

There's a Hoskins Electric Furnace for every laboratory use. Built in muffle, tube, and crucible designs. Bulletin sent on request.

Hoskins Manufacturing Company
457 Lawton Avenue, Detroit

Otis Bldg., CHICAGO
Oliver Bldg., PITTSBURGH
Grand Central Terminal, NEW YORK CITY
Tremont Bldg., BOSTON
Canadian Hoskins, Ltd., WALKERVILLE, ONT.

DEALERS!

Central Scientific Co., Chicago; Henry Heil Chemical Co., St. Louis; L. E. Knott Apparatus Co., Cambridge, Mass.; E. H. Sargent & Co., Chicago; A. H. Thomas Co., Philadelphia; Palo Company, New York; Scientific Materials Co., Pittsburgh; Bausch & Lomb Optical Co., Rochester.

H&M Thermometers

SIMPLICITY, RUGGEDNESS

Dependability, Accuracy Characterize H&M *Tycos* Thermometers, Recording and Indicating. Whatever the application, there's a *Tycos* Instrument for it. We make;

H&M Regulators, *Tycos* Mercury Operating Recording Thermometers, Glass Engraved Stem Thermometers, Hygrometers and Hydrometers Thermo-Electric and Radiation Pyrometers

A line complete and uninterrupted from fever thermometers to Fery Pyrometers. Every application met, and there are thousands.. Our installations for very critical and exacting manufacturers and to whom we can refer are to be found in every industrial point in the country.

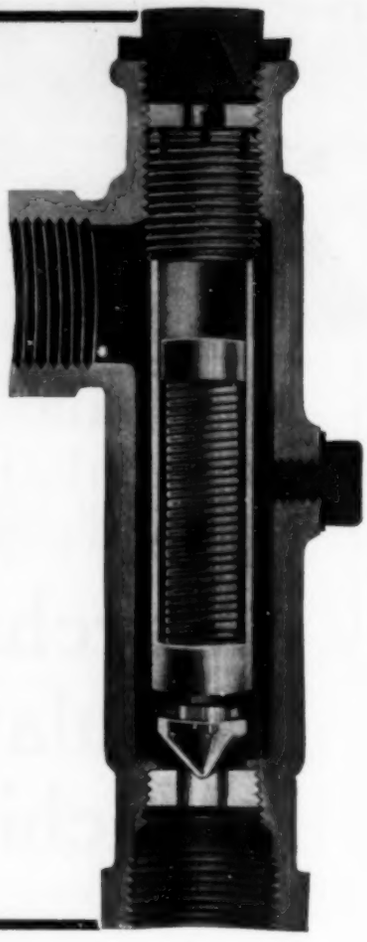
Correspondence will have immediate and courteous attention

H&M Division
Taylor Instrument Companies
Rochester, N.Y.

Do you know why the

Steam Trap SARCO

is used by nearly all the big industrial concerns?



THIS IS WHY—

The Steam Trap SARCO is operated by the expansion of a liquid operating a spirally corrugated tube. There is no other steam trap made which uses liquid expansion and none can use this enormously powerful and reliable operating medium without using also the SARCO tube. Therefore of all thermostatic traps the SARCO claims to be the most positive—and it can be supplied not only for vacuum heating systems but for low pressure and high pressure steam up to 200 lbs. Do you know any other thermostatic trap used successfully for pressures above 50 lbs. or even as high?

Then as to installation. The SARCO fits in anywhere (1" size measures only 7½ inches); it needs no floor space or building up, but can be used as an elbow or bend, in the discharge. Although it does just the same work, it is not a heavy, cumbersome affair like a float or bucket trap. It is not a tank but a piece of live pipe.

Price—it is the cheapest trap on the market and owing to the enormous increase in sales and improved manufacturing facilities, we have not had to increase prices in three years.

Take a trap on thirty days trial and prove what you gain in first cost, cost of installation, and in steam saved.

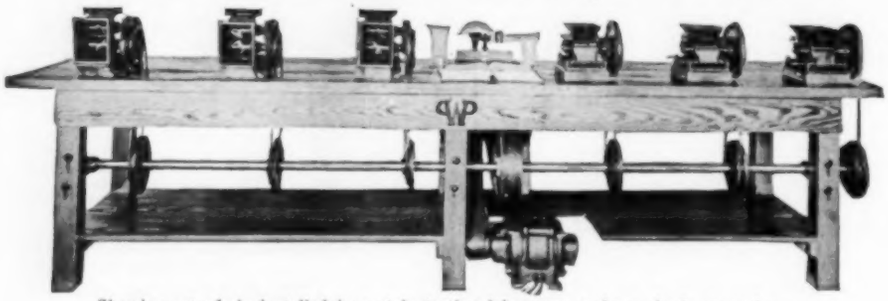
Write for Bulletin F 1.

Sarco Company, Inc., Woolworth Bldg., New York

Drexel Building, Philadelphia; New Telegraph Building, Detroit; and Monadnock Block, Chicago

PEACOCK BROS., MONTREAL, CANADA

W. & P. Laboratory Mixers



Showing set of six installed in certain testing laboratory to keep check upon the uniformity and quality of materials purchased

These machines are extensively used for experimental work generally.
They are readily taken apart to clean.
Can be supplied for hand drive or power drive.
For factory use W. & P. Mixers are made in many standard sizes up to 3000 gals.

We also Manufacture

Vacuum Kneaders — **Rapid Dissolvers and Rubber Machinery**

Filter Presses (high pressure)

Ask for literature.

Werner & Pfleiderer Company, Inc.

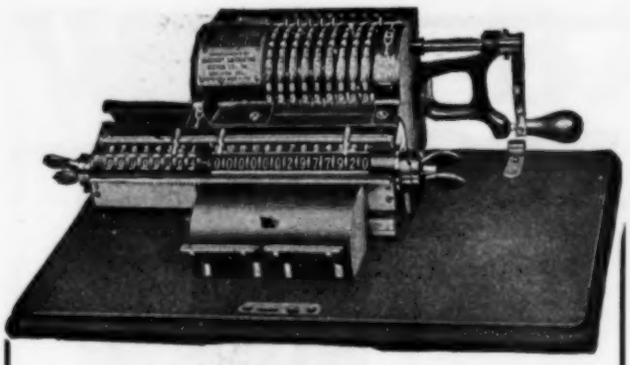
Factory and Main Office: Saginaw, Mich.

New York Office: 41 Park Row

Philadelphia Office: Drexel Bldg.

San Francisco Office: Pacific Bldg.

European Houses:
Cannstatt-Stuttgart, Paris, Moscow, Milan, Zurich, Hague, London, Berlin, Hamburg. Cologne, Frankfort, Vienna, Dresden, Peterborough



Work and prove this calculation in 12 seconds on the

Marchant Calculating Machine

Wt. sample taken for sulphur analysis. .3 gr.
Wt. $BaSO_4$ 0.6545
Percentage of sulphur in $BaSO_4$.. $\frac{32}{233.4} = 0.1371$
Percentage of sulphur in sample ..... $\frac{0.6545 \times 0.1371}{3} \times 100 = 2.99$

The Marchant can be used for calculating any chemical analysis in one-eighth or one-tenth the time required by an expert.

The difference in the final result would be that the expert would believe his result to be correct, while you *know* that the Marchant's work is correct, because it *automatically* proves each operation.

Prove to your complete satisfaction that it will save you money.

Placed in your office on free trial

Anyone can operate it with our instructions given when we place the machine. Ordinary employees become "experts" in the fullest sense of the word.

And you are not obligated to buy. The coupon will bring full details. Send it.

MARCHANT CALCULATING MACHINE CO.
Federal Realty Bldg., Oakland, Cal.

Gentlemen:

Please send me your Booklet M12 about the Marchant Calculating Machine.

Firm .....

Name .....

Address .....

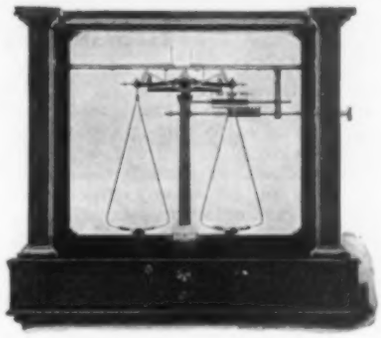
My business is.....

THIS

AINSWORTH

TYPE Q

Analytical Balance



With Improved Multiple Rider Carrier is used in the foremost laboratories where accuracy combined with speed are the prime requisites.

Send for Catalog A-4

Covering our complete line of Assay and Analytical Balances and Weights.

Wm. Ainsworth & Sons, DENVER COLO.

UEHLING

RECORDING GAUGES

Hydrostatic Principle
No Springs or Multiplying Levers

Instruments for measuring and recording CO_2, draft, temperature, pressure, absolute pressure, barometric pressure, vacuum, speed, etc.

POWER PLANT ECONOMY APPARATUS OUR SPECIALTY

Equip your boilers with continuous CO_2 Recorders and reduce your annual fuel consumption.

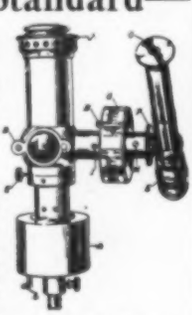
UEHLING INSTRUMENT CO.
Combustion Economists
2009 Empire Bldg., New York City

SCLEROSCOPE

The World's Standard—

For Hardness Testing

The SCLEROSCOPE is effecting great economies for Governments and manufacturers. BOOKLET S.

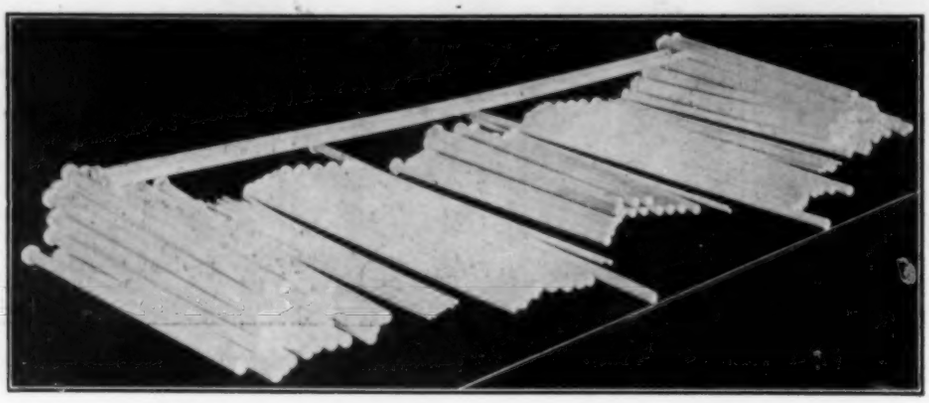


PYROSCOPE

For Heat Measuring

the PYROSCOPE (optical pyrometer) solves the industrial problem of quick heat measuring in shops, foundries, kilns, retorts, etc. CIRCULAR P.

SHORE INSTRUMENT & MFG. CO.
555-557 West 22d Street, New York



"USALITE" PYROMETER PROTECTION TUBES

A neutral refractory porcelain. Superior to all others.
Possess remarkable mechanical strength. Will neither bend nor corrode.
Are positively impermeable to gases at highest temperatures.

Manufactured by

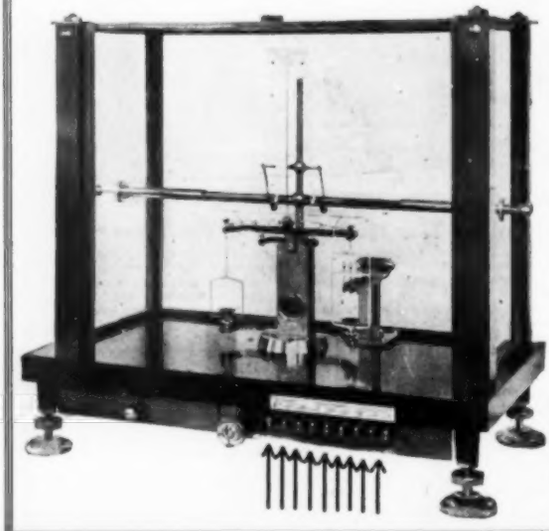
The Stupakoff Laboratories 6625-6639 Hamilton Ave., Pittsburg, Pa.

Works like a typewriter

The Heusser Assay and Analytical Balances

No accidental jarring or draught disturbances

Press one or more keys and the weights you want go down on the pan hanger and stay there. Raise the keys and the weights go back into place again. These operations are performed without opening the balance case. Rapid and accurate weighing is the result. Substantial and durable—all that a fine balance should be, plus the convenience of the automatic arrangement to save your time and render your work easy and sure. Send for full description—there are many interesting details that we will gladly explain.



Laboratory Apparatus
Chemicals Instruments
Coors Porcelain
Massco Clay Goods
Scorifiers Muffles

Assay Furnaces, Crushers, Pulverizers—we are headquarters for Laboratory Supplies. Ask for bulletins on various lines handled, or catalog of our complete line. We fill orders promptly.

Complete stocks carried in Denver, Salt Lake City and El Paso.

The Mine & Smelter Supply Co.

DENVER SALT LAKE CITY EL PASO

New York Office, 42 Broadway

Recording instruments for superintendent

View of kilns

Indicating instruments for operator

BROWN PYROMETERS

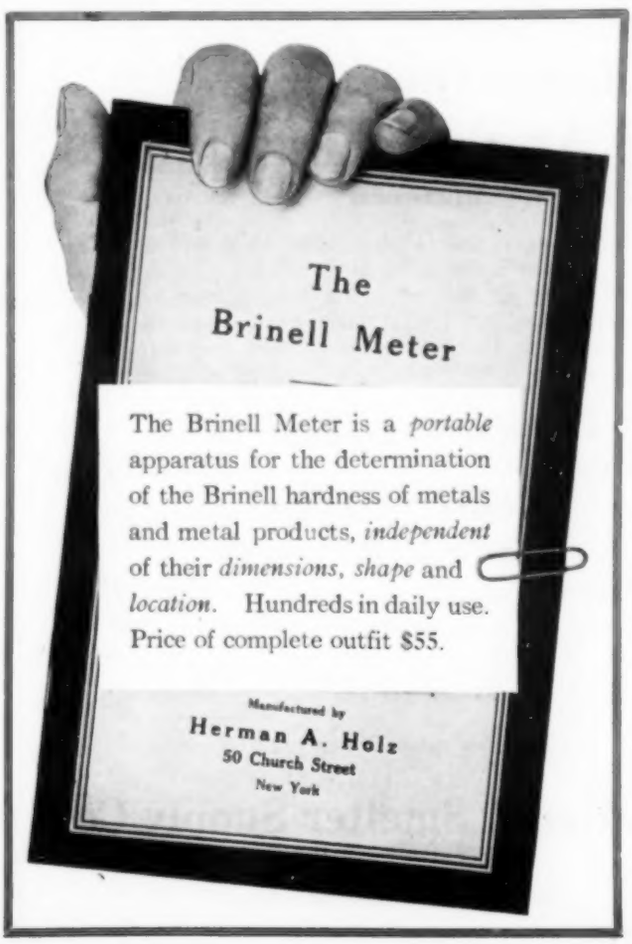
Do you want to measure the temperature of kilns, ovens, retorts, furnaces, flues or pipes? If so, there is a Brown High Resistance Pyrometer or a Brown Recording Thermometer to measure it. Give your operator an instrument to guide him and install recording instruments to check up his work. That is efficient management.

A 72 page catalogue with 100 illustrations is sent on request.

THE BROWN INSTRUMENT COMPANY

PHILADELPHIA, PA.

NEW YORK PITTSBURGH CHICAGO



The Brinell Meter

The Brinell Meter is a *portable* apparatus for the determination of the Brinell hardness of metals and metal products, *independent* of their *dimensions, shape* and *location*. Hundreds in daily use. Price of complete outfit $55.

Manufactured by
Herman A. Holz
50 Church Street
New York

Multiple-point Recording Potentiometer Pyrometer

Regarding Your Heat Treatment Processes

The heat treatment of steel demands a high degree of accuracy in the measurement of temperature. With the aid of an accurate pyrometer a skillful man can make use of inexpensive carbon steels and turn out a high grade product. On the other hand, an inaccurate pyrometer will certainly be the cause of inferior products, even from high grade material, and may spoil many a furnaceful of material.

To meet the special requirements of steel users we have developed the Potentiometer System of Pyrometry, having the necessary precision and reliability.

This system can be either indicating or recording. The recorder produces a graphic chart from which the temperatures can be read at any time, and by means of an automatic switch, one instrument can record the temperatures of as many as 16 thermocouples.

We would be glad to send you our new publication No. 875M, describing the Potentiometer System.

THE LEEDS & NORTHRUP CO., 4921 Stenton Ave., Philadelphia, Pa. 13

Gold Medal Award

Panama-Pacific Exposition
for

THWING

HIGH RESISTANCE MULTIPLE RECORD

PYROMETERS

Their Merits are Vouched for by Hundreds of Satisfied Users

Ask for our New General Catalog No. 8

Thwing Instrument Co.
3340 Lancaster Ave. Philadelphia, Pa.

Heraeus Le Chatelier *Pyrometers*

"The Ultimate Pyrometer"

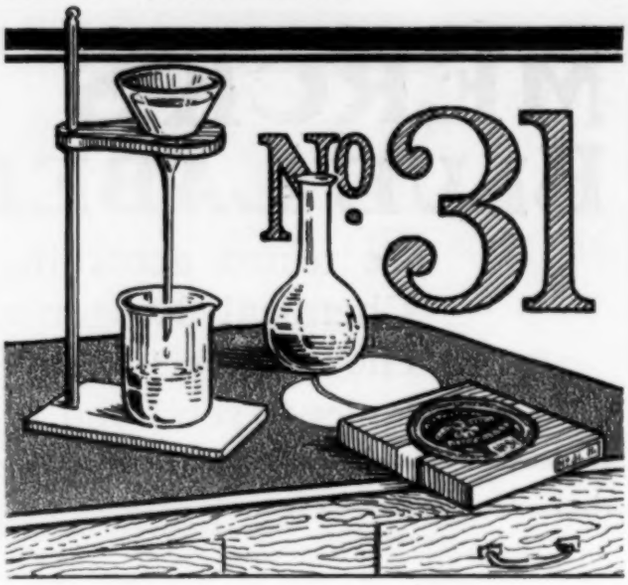
These instruments possess an accuracy sufficient for the most refined research work, and a practicability for industrial use which makes them cheaper than others less accurate.

Our new book "Facts worth knowing about Pyrometers in General and Heraeus Le Chatelier Pyrometers in Particular." Bulletin No. 10 will interest you. Gladly sent upon request.

HERAEUS RESISTANCE THERMOMETERS
for temperatures below 1300° F.

HERAEUS ELECTRIC FURNACES
Literature upon application.

CHARLES ENGELHARD
No. 30 CHURCH STREET
NEW YORK, N. Y.



FOR EXTREME RAPIDITY IN FILTERING—

gelatinous and large particle precipitates, WHATMAN No. 31—single acid washed—is supreme.

No. 31 has met with instant favor in metallurgical laboratories on account of its remarkable rapidity; it is not recommended, however, for fine precipitates.

For fine precipitates use WHATMAN No. 30, single washed, or Nos. 40 or 42, double washed.

WHATMAN
High Grade FILTER PAPERS

For purposes similar to those for which No. 31 is used, but when ashless paper is unnecessary, WHATMAN No. 4 is highly recommended—No. 2 for fine precipitates.

Samples, price list and supplies are obtainable from all laboratory supply houses

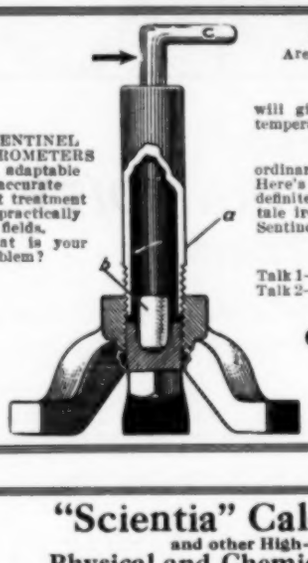
Are you using the WHATMAN grade best suited to your requirements? If in doubt, *write us.* There is a grade to suit your preference.

H. Reeve Angel & Co., Inc.
120 Liberty St., New York, N. Y.
Sole Representatives for U. S. A. and Canada

MERCK'S BLUE LABEL REAGENTS

are tested according to the book of standards, "Chemical Reagents: Their Purity and Tests." The analysis is on every label. Instruct your dealer to send you Merck's "blue label" goods only.

SENTINEL PYROMETERS are adaptable to accurate heat treatment in practically all fields. What is your problem?



Heat Treatment Talk No. 3—Annealing Steel Castings

Are you able to *definitely* control the temperature in annealing steel castings?

Sentinel Pyrometers

will give you the **temperature of the masses being annealed** (mass temperature) not just the furnace temperature which

Why the Waste Pile?

ordinary electrical pyrometers indicate.
Here's how it's done:—"Sentinel" Pyrometers are cylindrical shaped pellets having definite melting points of any desired temperature. Place in iron tube, a, with tell-tale iron rod, c, resting on Sentinel Pellet, b. When desired temperature is reached, Sentinel Pellet melts and tell-tale rod, c, lowers.

Inexpensive—Accurate—Simple

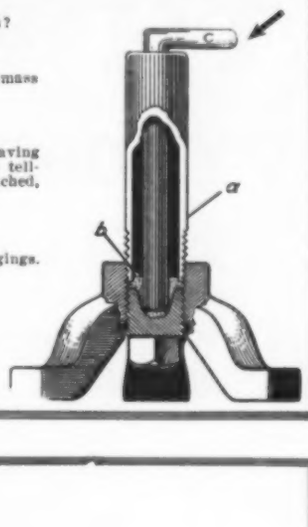
Other Heat Treatment Talks

Talk 1—General—Mass Temperature Work.
Talk 2—Carbonizing Work.
Talk 3—Annealing Steel Castings.
Talk 4—Annealing and Hardening Forgings.

They Are Free—Send for the ones you want.

Carl Nehls Alloy Co., 248 Brush St., Detroit, Mich.

At the left is cross-section showing "Sentinel" Pyrometer Pellet, b, contained in tube, a, placed in furnace at the spot so that it gets the same heat as the material being treated. When the desired temperature is reached the pellet melts and tell-tale rod, c, lowers as in figure at the right.



"Scientia" Calorimeters
and other High-Grade
Physical and Chemical Apparatus

Universal Laboratory Supports—Spectroscopes—Spectrometers—Cathetometers—High-Grade Thermometers—Balances, Weights, etc. Let us know your requirements and we will send catalogue.

Wm. Gaertner & Co., 5345-49 Lake Park Ave., Chicago

PYROLECTRIC INSTRUMENT CO

148 East State Street Trenton, N. J.

E. F. NORTHRUP, President and Technical Adviser.

Specialists in temperature-measuring apparatus

Our NORTHRUP PYROVOLTER is a new instrument with a new principle for the very accurate measurement of temperature with either base metal or noble metal thermo-couples. It reads electromotive force like a potentiometer, but deflects like a voltmeter. Send for our circular, "NORTHRUP PYROVOLTER."

Speed—Economy
Safety—Thoroughness

are always found in centrifugals manufactured by

Schaum & Uhlinger, Inc.

Glenwood Ave. and 2nd St. Philadelphia, Pa.

DIRECTORY CARDS

in Metallurgical and Chemical Engineering Afford the Professional Man a Circulation Among a High-Class Clientele.

RATES ON REQUEST

A Word to Employers

You can secure just the man you desire to strengthen your organization by placing an advertisement in the Searchlight Section of Metallurgical & Chemical Engineering.

This paper is read by progressive men, many of whom are ambitious for better positions than they now have. They study our "Positions Vacant" columns each week for opportunities for advancement.

You can get in touch with a number of these competent men and select the one best fitted for your needs, by stating in an advertisement in our Searchlight Section the experience and qualifications you require and telling what you have to offer. The cost will be only 3 cents a word, minimum charge $1.50 an insertion.

We suggest that you use in the advertisement either your own name, that of one of your employees, or a local post office box number or street address, so that the replies (letters and telegrams) will come direct to you. If you prefer to have the replies addressed to a box number in one of our offices, they will be enclosed in new envelopes and remailed to you promptly each day.

Hundreds of prominent employers now use this method of securing the men needed in their organizations. May we not help you also?

Metallurgical & Chemical Engineering
239 West 39th St., New York

Now Ready

The Analysis of Copper

AND ITS ORES AND ALLOYS

By **George L. Heath,** Chief Chemist, Calumet & Hecla Smelting Works, Mem. A. I. M. E., Am. Chem. Soc., etc.

292 pages, 6x9, illustrated, $3.00 net, postpaid.

The first connected account of the principal methods employed in the analysis of copper, its ores and alloys, by the leading refineries, foundries and custom sampling works.

The book is representative of the best practice. The author has had the broadest experience and shows a thorough familiarity with the methods, in general use, for the control of operations and valuation of material.

The work is intended for the technical chemist and the advanced student. Great emphasis is laid on the necessity of correct sampling.

Metallurgists' and Chemists' Handbook

By **Donald M. Liddell,** Consulting Metallurgical Engineer, and Managing Editor of the *Engineering and Mining Journal.*

603 *pages, 4 x 7, flexible leather, illustrated,* $4.00 *net, postpaid.*

A compact reference pocketbook of tables and data for the metallurgist and chemist.

Six hundred pages, packed with tables, formulae, constants, and similar reference data to supply the fact or figure which you would otherwise spend hours in searching for.

Metallurgical Calculations

By **Joseph W. Richards,** Head of the Department of Metallurgy, Lehigh University.

Part I—Chemical and Thermal Principles

208 *pages, 6 x 9, 47 problems.* $2.00 *net, postpaid.*
A revised edition of a book that is standard throughout the world.

Part II—Iron and Steel

236 *pages, 6 x 9, 53 problems.* $2.00 *net, postpaid.*

Part III—Non-Ferrous Metals

197 *pages, 6 x 9, 30 problems.* $2.00 *net, postpaid.*

McGRAW-HILL BOOK CO. INC.
239 WEST 39TH STREET, NEW YORK

LONDON: HILL PUBLISHING CO., LTD.
6 & 8 BOUVERIE ST., E.C.

Publishers of Books for Metallurgical and Chemical Engineering

The Flotation Process

By **Herbert A. Megraw,** Mining and Metallurgical Engineer, member Editorial Staff of the *Engineering and Mining Journal.*

250 *pages, 6 x 9, fully illustrated.* $2.50 *net, postpaid.*

A comprehensive discussion of the flotation process, covering both its theory and application.

It contains a record of flotation practice at many mills that have made a technical and practical success of it, and the methods followed are described in detail. *Theory and practice are brought up to the middle of* 1916.

FREE EXAMINATION COUPON

McGraw-Hill Book Co., Inc., 239 W. 39th St., New York.
You may send me the following on 10 days' approval:

.....

.....

I agree to return the books postage prepaid or remit for them within 10 days of receipt.
....I am a member of the A. I. M. E. or Am. Electro-Chemical Soc.
....I am a regular subscriber to Metallurgical and Chemical Engineering.

Signed .....

Address .....

.....

Note:—If not a subscriber to M. & C. E., or a member of the A. I. M. E. or Am. Electro-Chem. Soc. give business reference in margin. M-12-15

PUBLISHER'S PAGE [No. 2]

$120,000
Preferred Stock, Health Giving and Life Saving
Belgian Kiddies, Ltd.

(A Corporation to be organized under the laws of Humanity)

10,000 shares of a demand value of $12 each

Registrar—None* Trustees—Hoover, Honnold & Co.
*"Let not thy left hand"

We offer, subject to no over-subscription or prior allotment, $120,000 preferred stock, and as much more as we can get rid of, in Belgian Kiddies, Ltd., concerning which we are in receipt of full reports from H. C. Hoover, W. L. Honnold, Edgar Rickard, and other well known mining engineers, which we summarize as follows:

I. The object of this stock issue is to provide one meal per day for ten thousand Belgian children for the year 1917. Each share sold means 365 square meals for one child.
II. Our business is constantly growing and no estimate can be made of the requirements for 1918.
III. Security of the principal is absolutely assured by the personal management of H. C. Hoover and associates.
IV. That no cash dividends will ever be paid is absolutely guaranteed.
V. The stock is probably only part paid and is fully assessable.
VI. The stock is preferred as to holders, the subscribers being preferably taken from the members of the mining and metallurgical professions, and their wives and sisters.
VII. The demand value of the shares shall be $12 preferably payable in advance, but installments will be welcome if more convenient to the subscriber.

The legality of this issue has been passed upon by no one, but the committee can convince any one of its necessity. Applications for stock should be mailed at once as we desire to sell the allotment before Christmas.

Address Subscriptions to

BELGIAN KIDDIES, Ltd., *Room 2124,* **120 Broadway, New York City**

APPLICATION FORM

Preferred Stock $12.00 per Share.

I hereby make application for .....shares preferred stock of

BELGIAN KIDDIES, Ltd.

for which I contract to pay (in advance, semi-annually, quarterly, monthly; indicate method desired). I herewith enclose Check (or Money Order) for the sum of $....., payable to

HERBERT C. HOOVER, Chairman,
Room 2124, 120 Broadway, New York City

I direct that certificate for stock be made in the name of:

.....
.....
(Give full name and address).

Mail this application with check or money order.

PROFESSIONAL DIRECTORY

CHEMICAL ENGINEERS METALLURGISTS CHEMISTS ENGINEERS LABORATORIES ETC.

W. G. ABBOTT, Jr.
Research Engineer
Development of Inventions, Special Machinery and Industrial Processes.
Laboratory, WILTON, N. H.

BOOTH, GARRETT & BLAIR
Metallurgical Chemists
Established 1836
Analysis of special steels, ores and minerals. Water analysis, bacteriological and sanitary.
404-6 Locust Street,
PHILADELPHIA, PA.

N. L. HEINZ
Consulting Engineer
Metallurgy of Zinc and Manufacture of Sulphuric Acid.
1519 Oliver Bldg.,
PITTSBURGH, PA.

JOHN F. ABERNETHY
Lead Burning **Lead Lined Tanks**
Lead Work of every description
703 Myrtle Ave., BROOKLYN, N. Y.

BYRNES, TOWNSEND & BRICKENSTEIN
C. P. Townsend J. H. Brickenstein
Patent Lawyers
Experts in Electricity, Metallurgy, Chemistry, Electrochemistry.
918 F Street, Rooms 58, 59, 60, 61.
WASHINGTON, D. C.

HERCULES ENGINEERING CORPORATION
Complete Chemical and Electrochemical Plants
Reports, Plans, Specifications and Purchasing
304 Madison Avenue
NEW YORK CITY

W. J. ALCOCK
Consulting Chemical Engineer
Acids, Alkalies, Fertilizers, Copper, Extraction and Briquetting Plants
Rosslyn Mill Hill
LONDON, ENGLAND

Canadian Inspection and Testing Laboratories, Limited
Consulting and Analytical Chemists Inspecting and Metallurgical Engineers
Branches: Toronto, Winnipeg, Edmonton, Vancouver, New Glasgow.
Head Office & Laboratories, Montreal, Can.
A. Gordon Spencer, Chief Chemist

CARL HERING
Consulting Electrical Engineer
Tests, Examinations, Researches, Reports
Patent Litigation, Etc.
Electrical Furnaces, Thermal Engineering, Electrolytic Corrosion, Electro-Chemistry.
210 S. 13th St., PHILA., PA.

J. EDWARD BANGS
Established 1849
Ethical and Specialized Treatment of U. S. and Foreign Patents
and Patent Causes. Validity and Infringements. Chemical, Electrical and Mechanical Expert.
Suite 413, Barrister Building
WASHINGTON, D. C.

PHILIP L. DAVIS
Consulting Chemist and Chemical Engineer
Complete Chemical Plants furnished.
Laboratory and Experimental Plant at
TOMS RIVER, N. J.
NEW YORK OFFICE, 120 Broadway

MILTON HERSEY CO., LTD.
Industrial Chemists, Inspectors and Engineers
Analytical and Assay Work.
Steel, Asphalt, Cement Tests.
Research and Process Development.
Reasonable Rates. Prompt Service.
198 BROADWAY, NEW YORK
Phone: Cortlandt 515

JOHN H. BANKS
Formerly of Ricketts & Banks
Mining Engineer and Metallurgist
Special attention to problems in ore treatment—Complete Laboratories—Assays and Analyses.
61 Broadway, NEW YORK

ELECTRICAL TESTING LABORATORIES
Tests
80th St. and East End Ave.,
NEW YORK, N. Y.

DR. HAROLD HIBBERT
Consulting Chemist and Research Engineer
1105 Temple Building
TORONTO, CANADA

Benedict, Boyle & Stronck, Inc.
CONSULTING ENGINEERS
Management—Industrial Economics—General Engineering.
Specialty: Organization, Production and Labor Problems for the Chemical, Metallurgical and Mining Industries.
Peoples Gas Bldg. CHICAGO, ILL.

THE FITZGERALD LABORATORIES, INC.
F. A. J. FitzGerald, Pres.
NIAGARA FALLS, N. Y.
Electric furnace processes and inventions—Expert advice regarding design and construction of commercial plants, heat insulation and refractories.

HOWARD TESTING LABORATORIES
Physical Testing and Analysis Iron and Steel.
Alloy steels, alloys, foundry products and supplies—Prompt service—Operate day and night. Bell 'Phone 1000
LOCKPORT, N. Y.

GEORGE HILLARD BENJAMIN
Industrial Engineer
Patents and Patent Law
66 Broadway,
NEW YORK CITY, N. Y.

A. B. FOSTER
M. S. in Chemistry
Chemical, Process & Composition Patents—Soliciting, searches, opinions, validity, etc.
Ex-Examiner—Chemical Division Patent Office
527 Victor Building,
WASHINGTON, D. C.

Robert W. Hunt. Jno. J. Cone. Jas. C. Hallsted. D. W. McNaugher
ROBERT W. HUNT & CO.
Engineers **Chemists**
Metallurgists **Inspectors**
Examinations, Reports on Properties and Processes
2200 Insurance Exchange—Chicago

BLOCK CHEMICAL LABORATORIES
Plants for Dyes and Synthetic Chemicals
Consultation—Research
Continental and Commercial Bank Building
CHICAGO

EDWARD H. FRENCH & CO.
Consulting Chemical Engineers
Plant design, Construction and Improvement. Process investigation. Experienced in refining organic Chemicals. Coal tar products, wood distillation, acetic acid, acetone, turpentines, petroleum. bromine, pigments, insecticides, flotation oils.
606 Brunson Building, COLUMBUS, OHIO

THE INSTITUTE OF INDUSTRIAL RESEARCH
WASHINGTON, D. C.
Divisions of Metallurgy, Paint Technology, Food and Drug Products, Roads and Pavements, Chemical Engineering.
Processes developed—
Designs, specifications and superintendence—Tests of materials of construction.

PROFESSIONAL DIRECTORY

CHEMICAL ENGINEERS METALLURGISTS CHEMISTS ENGINEERS LABORATORIES ETC.

W. J. KEE
Chemical Process Engineer
Manufacture and Concentration of Sulphuric acid. Nitric and Hydrochloric acids. By-products.
Woburn, Massachusetts

CLARENCE W. MARSH
Consulting and Chemical Engineer
Personal constructive engineering service for investigation, organisation, design and operation in the chemical industry.
Engineering Designer of the Largest Electrolytic Alkali Plant in the World.
101 Park Ave., NEW YORK, N, Y.

Analyses Technical Reports Research
BERNARD ORMONT
Chemical Engineer
Design, investigation and development of mines and chemical plants and processes.
Patents Chemico-legal advice
Office and laboratory
104-106 John St., NEW YORK CITY
Phone John 2396

ISAAC H. LEVIN
(Formerly Chief Engineer and Chemist of the International Oxygen Co.)
Specialist in Electrolytic Gas Production and Synthetic Precious Stones
RESEARCH
186 Hillside Ave. Newark, N. J.
(Temporary Address)

RICHARD K. MEADE
Chemical, Mechanical and Industrial Engineer
Chemical Plants Designed, Constructed, Reorganized and Operated.
Processes Investigated.
The Law Building Courtland St.
BALTIMORE, MD.

C. L. PARKER
Ex-Examiner Chemistry U. S. Patent Office
Attorney-at-Law and Solicitor of Patents
McGill Bldg.
WASHINGTON, D. C.

Dr. CHARLES F. McKENNA
Consulting Chemist and Chemical Engineer
Expert in Technology and Testing of Materials
50 Church St.,
NEW YORK CITY

ARTHUR P. MONK
Certified Public Accountant
Telephone 4420-1 Broad
30 Broad Street, NEW YORK

FRANCIS J. PECK & CO.
Consulting Chemical Engineers
Chemical Plants designed, constructed, investigated, reorganized, and operated. Processes devised, developed and improved.
Williamson Bldg.
CLEVELAND, OHIO

T. G. MACDONALD
Chemical Engineer
Plans furnished upon application
LEAD BURNING CONTRACTOR
Estimates Given on Acid Chambers Glover & Gay Lussac Towers, Agitators and Lead Burning of Every Description
336 Sumner Avenue, BROOKLYN, N. Y.
Phone Bedford 8236 20 Years' Experience

MOORE & SIMONSON
Contractors of Lead Burning & Chem. Plumbing
133 Halsey St., BROOKLYN, N. Y.
LEAD BURNING
Specialists in the erection of Acid Chambers, Glover & Gay Lussac Towers, Concentrators & Contact Plants. Lead Burning for Pulp Mills, Bleacheries, Print Works, Electrotypers and General Chemical Apparatus of all descriptions.

PITTSBURGH TESTING LABORATORY
Research, Physical, Analytical and Bacteriological Laboratories
Design of Water Purification Plants
PITTSBURGH, PA.
James Otis Handy, Director of Laboratories.
Howard H. Craver, Chief Chemist.

OTTO MANTIUS
Consulting Engineer
Chemical Plants
Evaporators, Causticizers
Chemical Machinery
Woolworth Bldg. NEW YORK CITY

A. H. NEY, INC.
Consulting Chemists and Chemical Engineers
Experts in Coal-Tar Products and other Industrial Organic Chemicals
50 Church St., NEW YORK CITY

Validity and Infringements.
A. PRESS
U. S. Patent Attorney 3606
Resident European Experience
CONSULTING ENGINEER
NORMAN, OKLA.
Ex-Chemical Examiner U. S. Patent Office
Expert Foreign Prosecutions

DR. N. CAMPBELL
Analytical and Research Chemist
Bacteriologist
90 Puntine St. Jamaica, N. Y.

HAMLIN & MORRISON
Analytical Chemists
Established 1892
Forest Bldg., PHILADELPHIA, PA.

JOHN OGDEN
Metallurgist-Chemist
Electro-Metallurgy of Gold, Silver and Platinum
906 Filbert St., PHILA., PA.

ATTENTION ANALYSTS! SPECIMEN LABEL

SQUIBB'S REAGENTS

A new line added to our list of High Grade Chemicals

A TRIAL WILL CONVINCE

Send us your want list and we shall be pleased to quote prices

SQUIBB'S REAGENT

Sodium Carbonate Cryst.

$Na_2CO_3.10\ H_2O$

Contains:	In.	Per cent.
Chloride as Cl	(100 Gm.)	0.0005
Sulphate as SO_3	(100 Gm.)	0.005
Nitrate	(10 Gm.)	none
Phosphate	(100 Gm.)	none
Ammonium Salt	(20 Gm.)	none
Calcium	(100 Gm.)	none
Magnesium as MgO	(100 Gm.)	0.0013
Aluminum as Al_2O_3	(100 Gm.)	0.0001
Silicate	(20 Gm.)	none
Iron as Fe	(colorimetric)	0.0004
Sodium Hydroxide	(20 Gm.)	none
Loss at 120°C		62.20

The figures in parentheses express the quantities taken for each estimation.

LOT 15267

E. R. SQUIBB & SONS
MANUFACTURING CHEMISTS, NEW YORK

PROFESSIONAL DIRECTORY

CHEMICAL ENGINEERS METALLURGISTS CHEMISTS ENGINEERS LABORATORIES ETC.

RICKETTS & COMPANY, Inc.
Mining, Metallurgical and Chemical Engineers
Mines and properties examined—Advice as to development and operation—Ore treatment methods determined. Assays and analyses of all materials and products—Complete laboratories for research work.
80 Maiden Lane NEW YORK

A Card in the Professional Directory gives Maximum Results at a Minimum Expenditure.
Write us for Details.

WESTERN CHEMICAL LABORATORIES
Experts in Organic Analysis and Research
53 W. Jackson Blvd. CHICAGO, ILL.

SAM'L P. SADTLER & SON
Consulting and Research Chemists
Report on chemical and electrochemical processes. Analyze Industrial and Technical Products.
Office and Laboratory
210 South 13th St., PHILADELPHIA, PA.
Research Laboratory: CHESTNUT HILL, PA.

JOHN E. TEEPLE, Ph.D
Consulting Chemist, Chemical Engineer
Design of Chemical Plants, Investigation of Chemical Plants, Processes and Propositions.
50 East 41st St., NEW YORK

NORMAN T. WHITAKER
Patent Lawyer **Mechanical Engineer**
Former Examining Official U. S. **Patent Office**
Legal Building Washington, D. C.
Inquiries Invited

CARL E. SMITH
Analytical and Research Chemist
Metals, Alloys, Ores, Minerals, Chemical Products, etc.
5 Beekman Street, NEW YORK

LUDWIG A. THIELE, Ph.D.
Chemical Engineer
Design and Construction of Chemical Plants, Sulphuric Acid Plants (Tangent System), Fertilizer Plants, Extraction Plants (volatile solvents) } A Specialty
Supervision; Investigation of Plants, Processes and Propositions.
Hartman Building, COLUMBUS, OHIO

PROFESSIONAL CARD RATES:
One Inch—$24 a year
One-half Inch—$12 a year
(Twenty-four issues published each year)
SUBSCRIPTION INCLUDED

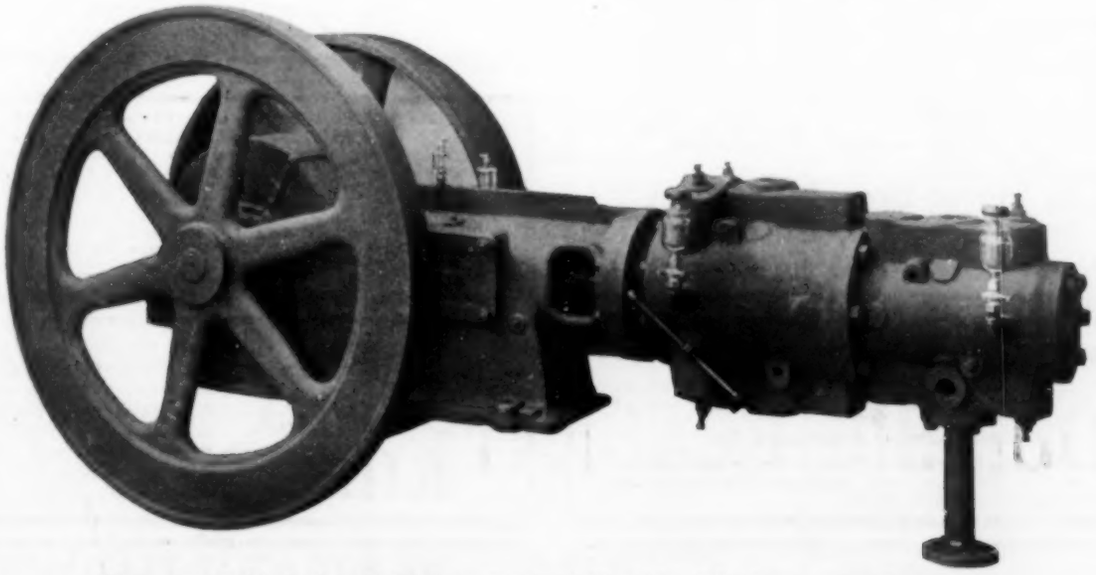
Write us for rates for cards in the Professional Directory. Metallurgical & Chemical Engineering, 239 West 39th St., N. Y. C.

O. N. THORESEN
Analytical Chemist
Analyses of Alloys, Ore, Iron, Coal, Limestones, e c.
308 N. Park St., Cadillac, Mich.

Welland Analytical Laboratory
Analytical & Research Chemists
37 Griffith St., Welland, Ont.

CHLORINE COMPRESSORS

For Low Pressure Service and High Pressure Liquid Work



The above Unit furnished to largest liquid chlorine manufacturers in this country and abroad

Hercules Engineering Corporation, 304 Madison Ave., NEW YORK CITY

SEARCHLIGHT SECTION

MACHINERY AND APPARATUS
IMMEDIATE DELIVERY

Evaporators
Shelf Dryers
Rotary Dryers
Drum Dryers
Stills
Kettles
Chemical Stoneware
Filter Presses

MACHINERY UTILITIES CO., Inc.
304 MADISON AVE., NEW YORK CITY

Electrolytic Plant

We are dismantling the plants of the U. S. Reduction & Refining Company in Colorado and have a complete electrolytic plant for the manufacture of chlorine gas. 99 cells 5′ 3″ x 12 x 12 cast iron, each equipped with bus bar copper 4′ 8″ x 1 x 3-16, 10 lead rods 7/8 x 10″ and 10, 4 x 4 x 12 electrodes. Can be secured at a bargain. In these plants are over 15,000 tons of machinery of every description used in the chlorination process. Send for list.

The Morse Bros. Machinery & Supply Co.
Denver Colorado

FOR SALE
3— 5′ x 6′ Heavy Duty Silex Lined **Pebble Mills**, $300 each.
5—6′ x 7′ Heavy Duty Silex Lined **Pebble Mills**, $500 each.
The National Products Company, East Liverpool, Ohio.

Do not sell—or do not think of selling
Scrap Platinum
or gold and silver scraps in any form until you have gotten in touch with us. We need these metals in the manufacturing of our own specialties and can pay higher prices than others who do not have our manufacturing and selling advantages. Consignment held subject to your approval of our offer.
THOMAS J. DEE & CO.
Gold, Silver and Platinum Refiners
Office: Mallers Bldg. Smelting Works: 317 E. Ontario St.
CHICAGO, ILL.

We pay Highest Prices For Scrap Platinum
Now is the time to dispose of platinum—do not wait until the price goes lower. Estimate or remittance by return mail. Reference if desired.
Miller Smelting & Refining Co.
Ellastone Bldg., E. Fourth St. & Prospect Ave., Cleveland, Ohio
We also buy palladium and mercury and refine gold, silver and other precious metals.

FOR SALE
ROTARY KILN
4-ft. diameter, 45 ft. long, excellent condition, suitable for graphite, cement or fertilizer. Immediate delivery and cheap. Address Enameled Metals Company, Box 678, Pittsburgh, Pa.

100 Bbl. **Steel Storage Tanks**
Immediate delivery.
Also 50 and 65 Bbl. for prompt delivery.
Wire, 'phone or write us for prices.
The National Products Company, East Liverpool, Ohio.

WE BUY SCRAP PLATINUM
or any material containing Gold, Platinum or Iridium
WE PAY MARKET PRICES
Consignments held subject to your acceptance of our offer.
Goldsmith Bros. Smelting & Refining Co.
Chicago, Heyworth Bldg. **New York, 20 John St.**
Seattle, Green Bldg. **Toronto, 24 Adelaide St., W.**

SEARCHLIGHT SECTION

Get your Wants into the Searchlight

ADVERTISING RATES

Under "Positions Wanted," including Salesmen looking for new connections, Evening Work Wanted, etc. undisplayed advertisements cost **two cents a word,** minimum charge 50 cents an insertion, **payable in advance.**

Under "Positions Vacant," including Agents and Agencies Wanted, Representatives Wanted, Salesmen Wanted, Partners Wanted, Business Opportunities, Employment Agencies, and Miscellaneous For Sale, For Rent, and Want ads; also Auction Notices, Receivers' Sales, Machinery and Plants For Sale or Wanted, undisplayed advertisements set solid in one paragraph, cost **three cents a word,** minimum charge $1.50 an insertion.

Machinery advertisements (undisplayed) set with a paragraph for each item, or tabulated, are charged at 25 cents a line.

If replies are in care of any of our offices, allow five words for the address.

All advertisements for bids (Proposals) cost $2.40 an inch.

ADVERTISEMENTS IN DISPLAY TYPE

cost as follows for single insertions:

⅛ p. (1⅛x3⅜ ins.)	$5.00	1 in. (1x2⅛ ins.)	$3.00
¼ p. (2⅜x3⅜ ins.)	10.00	4 inches (4x2⅛ ins.)	11.60
¼ p. (5x3⅜ or 2⅜x7 ins.)	20.00	8 inches (8x2⅛ ins.)	22.40
½ p. (10⅛x3⅜ or 5x7 ins.)	40.00	15 inches	40.50
1 page (10⅛x7 ins.) 30 inches	$80.00		

For space to be used within one year, to be divided to suit requirements of advertiser, provided some space is used in each issue following first insertion:

3 pages	$75 a page	12 pages	$60 a page
6 pages	70 a page	18 pages	55 a page
9 pages	65 a page	24 pages	50 a page

In replying to advertisements, do NOT enclose original testimonials, or anything that you may want returned. State your qualifications in as concise and neat a manner as you can and enclose COPIES of testimonials. In machinery ads, use a local name or address if possible so that readers can wire direct and get quick replies.

FOR SALE

Still—For Sale

500 Gallon Column Still for Alcohol Fractions—been used only for experiment. Price, $1,500, f.o.b. New York. Blue Print. R. H. Horne, 118 Fifth Ave., New York.

Stock-Taking Time

Now is the time to turn the surplus stock of metals you have on hand into cash. We buy all grades of scrap metals, small lots as well as large lots. Write us today and tell us what you have and we will be pleased to quote you prices. National Metal & Rubber Company, 30-31 India Wharf, Boston, Mass.

Enameled Kettle for Sale

Elyria make, closed jacketed, provided with agitator, coil in jacket, and special stuffing box jacket construction. Size 3' diameter, 2' 10" waist, capacity 150 gallons. Is brand new and ready for immediate shipment. Blue-print on application. Antoine Chiris Co., Delawanna, N. J.

Glass Containers

For Sale—27 twenty gallon capacity green glass containers 22" in diameter, 30" high, with openings from two to two and one-half inches, flat bottom. Purchaser to crate. Monmouth Chemical Co., 140 Cedar St., New York, N. Y.

Molybdenum Property for Sale

Four claims, patented, developed by 700-foot incline shaft. Ore developed 60,000 tons, averaging 1½% molybdic acid, five ounces silver, 5 per cent lead. No equipment now on property. Hoisting, compressor and concentrating equipment needed. Ore in sight should yield $500,000 profit. Will sell three-fifths interest for $75,000, of which $50,000 will go into equipment and development. Subject to examination of engineer. No triflers need apply. Quick action requisite. H. E. Davis, 604 I. W. Hellman Building, Los Angeles, Cal.

Machinery Bargains

that *are* Bargains can be secured from

"Zelnicker's" Bargain List

ALSO

Tank, Car and Rail Bargains

When you need anything and want a Bargain, write to the Bargain House

ZELNICKER IN ST. LOUIS

325 Locust Street

423 First National Bank Bldg., Chicago

910 Hennen Building, New Orleans

FOR SALE

Dynamo for Sale

For Sale: a 50 volt, 1200 ampere dynamo, made to order and never used. Ready for prompt delivery. Address Chas. E. Baker, 305 So. La Salle St., Chicago, Ill.

Plant for Sale

Property 148 ft. x 389 ft., formerly occupied in Philadelphia by N. & G. Taylor Co.'s Tinplate Works, Delaware Ave. and Tasker St., Philadelphia. (Plant recently removed to Cumberland, Md.)

Buildings of substantial, heavy mill construction, artesian well, pump, and 40,000 gallon storage tank, electric elevator, power equipment. Railroad connections with all lines entering the city.

Two blocks from Delaware River front—15 minutes from banking center. Convenient access via new Delaware Ave. improvement to all docks and factories along the river front.

N. & G. TAYLOR CO.

300 Chestnut St., Philadelphia, Penna.

MISCELLANEOUS WANTS

Rotary Kiln

Wanted—One rotary kiln, 6' x 120' or 7' x 125' complete; also one rotary cooler about 4' x 30'. Campbell Stone Co., Indian River, Mich.

Volumes for Exchange

Journal of the Soc. of Chem. Ind., V. 24-29; Chem. Centralblatt, V. 75 to 81; Berichte der d. chem. Ges., V. 37 to 43; Rauter, Betriebsmittel der technischen Chemie, all bound in cloth; and VIIIth Int. Cong. of App. Chem., complete set; J. Am. Chem. Soc., odd numbers of V. 26-29, unbound. Will exchange for Chem. Centralblatt, portions previous to 1900, or for bound volumes of other chemical or technical journals. Address Box 1028, Met. & Chem. Eng.

WANTED—MACHINERY

One, about 350 gal. porcelain-lined **Kettle.**

One drum **Grinder.**

One large or medium sized **Nitrator.**

One large or medium sized **Reducer.**

Box 1020, Met. & Chem. Eng.

MISCELLANEOUS WANTS

Celluloid Wanted

We are large purchasers of celluloid and in the market for the following: Raw celluloid, nitro cellulose (10 to 11 per cent) for same. Also clean, white, celluloid scrap. Write full particulars with prices and samples to Box 1053, Met. & Chem. Eng.

Wanted

Carbon or Graphite Electrodes

Four, six or eight-inch diameter, any length.

Advise what you have in stock and price.

Box 1041, Met. & Chem. Eng.

Wanted

Mechanical Roasting Furnace

Small capacity, four to six tons ore per twenty-four hours.

Write Box 1042,
Met. & Chem. Eng.

Your Advancement

is largely in your own hands—it is doubtful if any one else is worrying over it

Better positions are constantly being secured through small advertisements in the "Positions Wanted" Columns of *Metallurgical and Chemical Engineering.*

50 cents for 25 words

SEARCHLIGHT SECTION

POSITIONS WANTED

CHEMICAL engineer, experienced in developing, construction and operating plants for the manufacturing of sulphuric and nitric acid, fertilizer, coal tar and its pure by-products here and abroad, desires connection with firm which requires a manager, constructing engineer or research chemist capable of getting results. Coal tar industries preferred. Box 839, Met. & Chem. Eng., 1570 Old Colony Bldg., Chicago, Ill.

CHEMICAL engineer, University graduate, now in charge of nitric acid plant, wishes to change. High grade executive and technical chemist. Box 1030, Met. & Chem. Eng.

CHEMICAL engineer, successful in the introduction of new processes in the manufacture of coal tar products. Experienced in construction, plant layout, efficiency work and costs. M. I. T. graduate. Salary $175. Now employed. Age 29. Box 1035, Met. & Chem. Eng.

CHEMICAL Engineer, college graduate, 34 years old, experienced in manufacture of sulphuric acid (chamber or contact process), nitric, muriatic and hydrofluoric acids, soda salts, alums and many other heavy chemicals. Steady, reliable, with ability to handle men. Best references. Box 1052, Met. & Chem. Eng.

CHEMIST and Chemical Engineer who has good practical experience in continuous and non-continuous distillation processes, vacuum pans, pumps, filtration, etc., desires change. Recently completed erection of chemical plant. Would like position with chance of working up. Box 1027, Met. & Chem. Eng., 1570 Old Colony Bldg., Chicago, Ill.

CHEMIST (28), graduate, laboratory and factory experience, wishes position. Moderate salary. Box 1026, Met. & Chem. Eng.

CHEMIST—Research—Twenty years' experience; can analyze and reproduce any product on the market. Research, Room 303 E., 30 Church St., New York City.

CHEMIST, with several years' experience, desires a position with a manufacturing concern. Box 1019, Met. & Chem. Eng.

CHEMIST, young man, five years' experience in analysis of iron ores, steel, paint and varnish materials, wishes position in New York City. References furnished. Can report on short notice. Box 1036. Met. & Chem. Eng., 1570 Old Colony Bldg., Chicago, Ill.

CHEMIST, 1912, laboratory research, and factory experience. Employed in superintending the construction, developing and operating of a new electro-chemical industry. Desires position requiring research and executive ability. Excellent references. Knowledge of German. At present employed. Box 1046, Met. & Chem. Eng.

CHEMIST, Ph.D., desires high grade position. Industrial research preferred. Special training in chemical technology. Four years' experience in research and analytical chemistry. Now employed. Box 1044, Met. & Chem. Eng.

CHEMIST, young, energetic, high school and 5 years Cooper Union, desires position with manufacturing concern. Box 1045, Met. & Chem. Eng.

COAL tar expert, graduate M. I. T., wants postion as manager or assistant manager in manufacturing concern. Thoroughly experienced in manufacture of coal tar products and other bituminous materials. Can handle men and correspondence. Now employed by large corporation but desires change, preferably to smaller concern. Age 30. Salary to start, $2,500. Box 1034, Met. & Chem. Eng.

ELECTROMETALLURGIST experienced in operation and research. Technical graduate. 10 years' experience. Box 1025, Met. & Chem. Eng.

POSITIONS WANTED

ELECTROCHEMIST, graduate Mass. Inst. of Tech., class of 1915, thorough training in electrochemical, chemical, and electric engineering; at present, and for the year past in charge of the Chemical Laboratory of large manufacturing plant, desires position in or around New York City. Box 998, Met. & Chem. Eng., Leader News Bldg., Cleveland, O.

GRADUATE, Chemist, five years analytical, research and supervising experience, wants position with chemical company. Box 1012, Met. & Chem. Eng.

GRADUATE, mechanical engineer, 25, three years' experience, now with metallurgical company in New York district, desires position with similar company. Capable draftsman and designer, mechanical and structural. Box 985, Met. & Chem. Eng.

MASSACHUSETTS Institute of Technology graduate who has had unusual experience in connection with sales, advertising and purchasing as well as laboratory work and in charge of paper mill manufacturing operations, desires position. Originality and excellent executive ability. Moderate inital salary where there is good fieid for advancement. Box 1022, Met. & Chem. Eng.

METALLOGRAPHIST and chemist, graduate Eastern scientific school, five years' experience, with thorough knowledge of metallographic and metallurgical research methods and of inorganic chemistry; seeks opportunity for investigation of steels or alloys. Excellent references. Now employed. Box 1043, Met. & Chem. Eng.

MINING and mechanical engineer, 31, at present night superintendent of large chemical plant, seeks executive position. Experienced in construction, maintenance and handling of labor. Box 1001, Met. & Chem. Eng.

WANTED—Position in industrial research chemistry. Cornell University graduate. About three years' general analytical experience. Address Miss Brown, Box 1051, Met. & Chem. Eng.

POSITIONS VACANT

ALLOY metallurgist fully conversant with the manufacture of ferro manganese and ferro molybdenum as well as erection of necessary plant, may find engagement with reliable and financially strong concern. For full particulars, address Box 1004, Met. & Chem. Eng., 501 Rialto Bldg., San Francisco, Cal.

AN ENGLISH spelter company, limited, with works in England, wishes to communicate with an engineer having a thorough up-to-date practical knowledge of the spelter trade and the most modern plant and buildings as now adopted in the States. All privacy will be observed. Liberal terms would be arranged in keeping with results. Box W 346, care of Dawson's, 121 Cannon Street, London, E. C., England.

CHEMICAL Engineer wanted. Man capable of handling chemical factory producing phosphoric acid and phosphate of soda. Should be familiar with evaporators and filtering apparatus and have a knowledge of other phosphoric acid products. Salary made satisfactory to right man. Box 997, Met. & Chem. Eng.

COLOR chemist wanted, who has been employed in manufacturing coal tar dyes, and who can undertake the development of additional dyes. Box 1031, Met. & Chem. Eng.

LABORATORY mechanic and glass blower wanted, with experience in electrode work for factory in Middle West. Give full details with wages expected in first letters. Box 1021, Met. & Chem. Eng., 1570 Old Colony Bldg., Chicago, Ill.

POSITIONS VACANT

METALLURGICAL CHEMIST: Experienced in electrical reduction of ferro alloys, particularly tungsten, molybdenum and vanadium. Must make analyses of concentrates and ferros and have knowledge of preparing batches for reduction. State age, training, former experience, references and salary expected. Box 1037, Met. & Chem. Eng.

METALLURGIST or metallographist wanted to take charge of heat treating, calibration of pyrometers, etc. In replying state age, whether married, experience and minimum salary desired for start. Box 1047, Met. & Chem. Eng., 935 Real Estate Trust Bldg., Philadelphia, Pa.

WANTED as superintendent in the United States, metallurgist experienced in smelting and refining of tin ores and concentrates. Give full references and past experience. Box 983, Met. & Chem. Eng.

WANTED—Chemist as assistant superintendent in plant at Newark, N. J., manufacturing dye intermediates. Must have had actual manufacturing experience in this line. Splendid opportunity for right man. State age, training, experience and salary expected. Box 1032, Met. & Chem. Eng.

YOUNG technical graduate familiar with manufacture of carbon electrodes by extension process for work in Research Department. The Carborundum Co., Niagara Falls, N. Y.

YOUNG electro chemist or chemical engineer for research laboratory. State training, experience, salary desired. The Carborundum Co., Niagara Falls, N. Y.

EMPLOYMENT AGENCIES

Results Count

We are filling monthly hundreds of positions calling for the higher grade of employees. We have built up a force of employment experts who devote their entire time and energy to studying the requirements of various employers, and in searching for the men to meet them. By advertising and special searches we keep constantly available comprehensive listings of applicants, listing only those of proved ability and integrity.

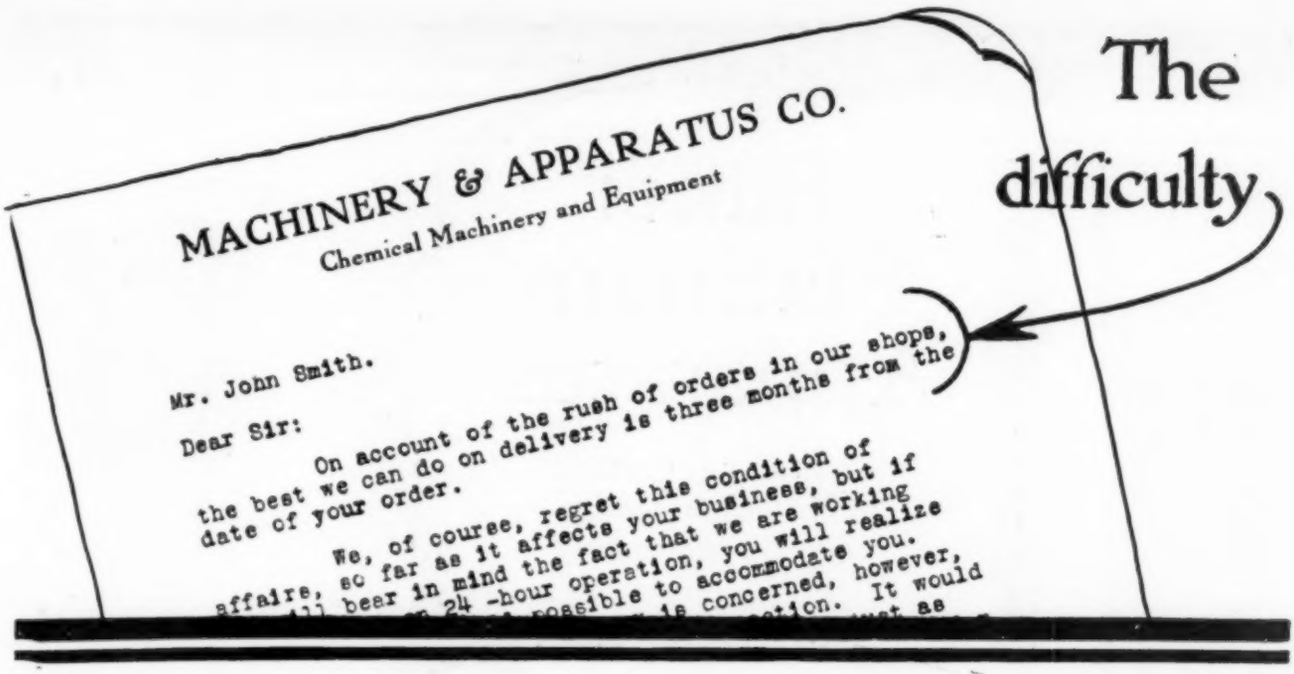
We offer you an expert service without cost. When contemplating changes in, or additions to, your force, phone, wire or write us your requirements.

National Employment Exchange

Officers and Directors:

Otto T. Bannard, President.
John R. MacArthur, Vice-President.
Francis L. Hine, Treasurer.
Eugene H. Outerbridge, Secretary.
Robert W. DeForest. Newcomb Carlton.
L. F. Loree. Arthur Williams.
G. S. Anthony, General Manager.

30 Church Street, New York City


The difficulty
MACHINERY & APPARATUS CO.
Chemical Machinery and Equipment
Mr. John Smith.
Dear Sir:
On account of the rush of orders in our shops, the best we can do on delivery is three months from the date of your order.
We, of course, regret this condition of affairs, so far as it affects your business, but if bear in mind the fact that we are working 24 -hour operation, you will realize possible to accommodate you. is concerned, however, It would

Manufacturers of Machinery and Equipment for the Chemical Industries are doing their utmost to supply the insistent demands of chemical manufacturers for quick and quicker deliveries. It's rush—*rush*—RUSH—*Double Rush*—in their shops, day and night, but still the orders come, and still the demand goes on. Many chemical manufacturers have solved their problems by purchasing and using second-hand machinery and apparatus until the new equipment can be delivered. To quickly locate the equipment you need so much,

Use the Searchlight Department of *Metallurgical and Chemical Engineering*

It pays—quick

You will be put in touch *at once* with owners who have such apparatus for sale. Searchlight ads reach into every nook and corner of the chemical and metallurgical industries. No matter how small the ad, or how inconspicuous, it cannot be hidden. There are no pages in the publication more thoroughly scanned, more carefully read, than the Searchlight ads.

It pays—big

Sell Discarded Apparatus

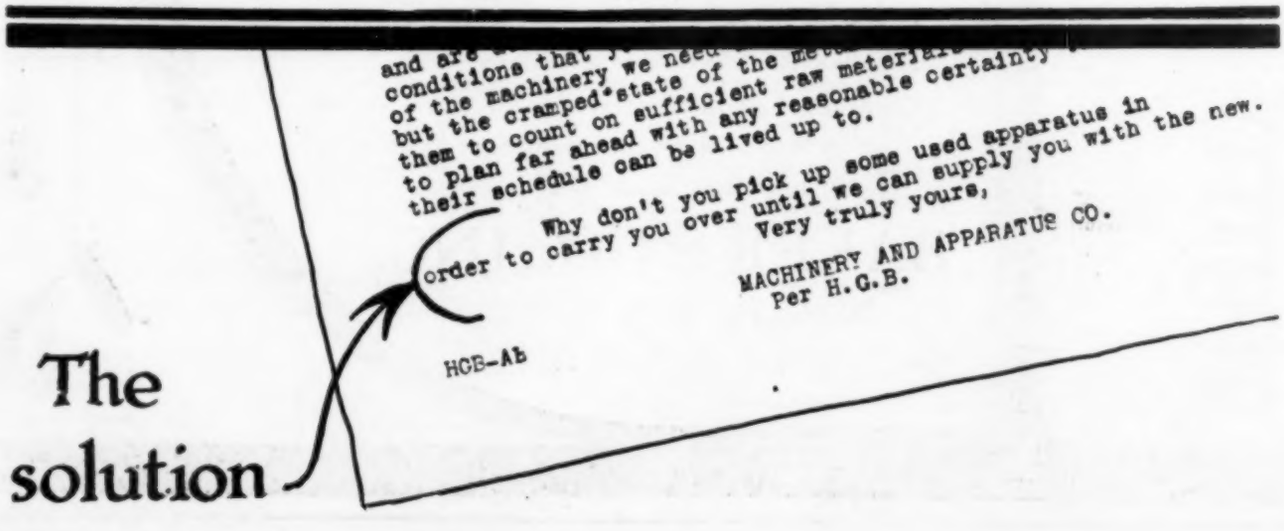
There is a waiting market for any and every piece of Machinery or Equipment which will aid in the manufacture or storage of chemical or metallurgical products. Let this thought be the father to the act of writing out a statement of what you have for sale, to be inserted in the Searchlight Department of "Met. and Chem." It is read by the BUYERS.

Get the Help You Need

Every incompetent in a job keeps some competent man out of it. The proper employee for the place can be found—by using the Searchlight Department. WORKERS read "Met. and Chem."

Do You Want a Position?

There are lots of them open—there is a market for your abilities. A "Met. and Chem." Searchlight Ad will put you in touch with EMPLOYERS. Advertising rates are low and returns quick.


The solution
conditions that
of the machinery we need
but the cramped state of the
them to count on sufficient raw materials
to plan far ahead with any reasonable certainty
their schedule can be lived up to.
Why don't you pick up some used apparatus in
order to carry you over until we can supply you with the new.
Very truly yours,
MACHINERY AND APPARATUS CO.
Per H.G.B.
HGB-Ab

Baker Platinum Apparatus

Standard Quality in Materials, Design and Workmanship

You can depend upon any and all Baker Platinum Ware to give the highest satisfaction. No piece is too small to receive our greatest care; no order can be so large as to tempt us to relax our vigilance in the slightest degree.

We make all forms and sizes of Platinum Ware for Chemical and Physical purposes. Special shapes and designs to order.

Old Platinum Ware reshaped, repaired, purchased or exchanged for new.

"Data Concerning Platinum" sent on request.

BAKER & CO., INC.

Newark, N. J.

New York Office, 30 Church St.

WHAT ADVERTISERS OFFER TO READERS

Classified Index of Products Advertised in This Issue by Representative Manufacturers and Dealers

Acid Chamber Tower Packing
Knight, M. A.
Laclede-Christy Clay Products Co.

Acid Concentration Apparatus
Pratt Eng. & Machine Co.
Thermal Syndicate, Ltd., The.

Acid Eggs
Bethlehem Fdry. & Mach. Co.
Buffalo Fdry. & Mach. Co.
Devine Co., J. P.
Elyria Enameled Products Co.
Fulton Foundry Co.
Knight, M. A.
Stearns-Roger Mfg. Co.
Stuart & Peterson Co.
U. S. Cast Iron Pipe & Fdry. Co.
U. S. Stoneware Co.

Acid Fans
Stearns-Roger Mfg. Co.
Sturtevant Co., B. F.
U. S. Stoneware Co.

Acid Filters
General Filtration Co., Inc.
Knight, M. A.
U. S. Stoneware Co.

Acid Pitchers
Knight, M. A.
U. S. Stoneware Co.

Acid Proof Brick
See Brick, Acid Proof

Acid Proof Chamber Tower Packing
Knight, Maurice A.

Acid Proof Chemical Stoneware
Knight, Maurice A.

Acid Receivers
U. S. Stoneware Co.

Acid Resisting Glass Enameled Apparatus
Elyria Enameled Products Co.
Pfaudler Co., The.
Stearns-Roger Mfg. Co.
Stuart & Peterson Co.

Acid Ware (Vitrified Clay)
Knight, M. A.

Agitators
General Filtration Co., Inc.
U. S. Stoneware Co.

Air Compressors
General Electric Co.

Air Filters
Simon, Buhler & Bauman.

Air Separators
See Separators, Air

Air Washers
Carrier Engineering Corporation.
Webster & Co., Warren.

Alloys: *See Ferro-Alloys*

Alloys, Special
Goldschmidt-Thermit Co.
Lavino, E. J., & Co.
Norton Laboratories, Inc.

Aluminum
Electric Smelt. & Alum. Co.

Analytical Apparatus
Ainsworth, Wm., & Son.
Hoskins Mfg. Co.
Mine & Smelter Supply Company.
Palo Co.
Schaar & Co.
Thomas Co., Arthur H.

Analyzers, Gas & Automatic
Williams Apparatus Company.

Anodes, Graphite
Acheson Graphite Co.

Asbestos Cloth, Yarn, Banding Tape and Fibre
Asbestos Protected Metal Company.

Assayers: *See Professional Directory, Pages* 89, 90, 91

Automatic Car Drive Systems
Pratt Eng. & Machine Co.

Automatic Weigh. Machs.
Pratt Eng. & Machine Co.
Werner & Pfleiderer Co.

Balances
Ainsworth, Wm., & Sons.
Mine & Smelter Supply Co., The.

Balances and Weights
Ainsworth, Wm., & Son.
Gaertner, Wm., & Co.
Mine & Smelter Supply Company.
Palo Co.

Ball Mills
See Mills, Ball, Pebble, Tube

Barrels—Bilge Steel
Detroit Range Boiler Co.

Barrels—Steel Agitator
Detroit Range Boiler Co.

Barrels—Steel Open Head
Detroit Range Boiler Co.

Bauxite
Laclede—Christy Clay Products Co.
Lavino, E. J., & Co.

Beakers
Heroid China & Pottery Co.
Fry, H. C., Glass Co.

Belt Conveyors
Caldwell, H. W., & Son Co.
Stephens-Adamson Mfg. Co.
Webster M'f'g. Co., The.

Bins, Steel and Concrete
Brown Hoisting Machinery Co.

Bleaching Powder
Solvay Process Co.
Wing & Evans, Inc.

Blowers, Fan or Positive Pressure
Abbé Eng'g Co.
Abbé, Paul O.
Buffalo Forge Co.
Connersville Blower Co.
Nash Engineering Co.
P. H. and F. M. Roots Company.

Blowers, Flotation
Connersville Blower Co.
Nash Engineering Co.
Roots, P. H. & F. M. Co.

Boats, Combustion
See Combustion Boats

Bolting Cloth, Silk
Abbé Engineering Co.
Abbé, Paul O.

Books
McGraw-Hill Book Company.

Brick, Acid Proof
Harbison-Walker Refractories Co.
Knight, M. A.
Laclede-Christy Clay Products Co.
Milton Brick Co.
Sittig, J. W.
U. S. Stoneware Co.

Brick and Clay, Fire
See Fire Brick and Clay

Brick Insulating (Sil-O-Cel)
Kieselguhr Company of America.

Brinell Machines
Holz, Herman A.

Brushes, Carbon
National Carbon Co.

Buckets, Clamshell & Drag Line
Brown Hoisting Machinery Co.

Bucket Elevators
Stephens-Adamson Mfg. Co.
Webster M'f'g. Co., The.

Burners, Gas and Oil
Rockwell, W. S., Co.

Burners, Sulphur
See Sulphur Burner

Calcium Carbide
Union Carbide Co.

Calculating Machines
Marchant Calculating Machine Co.

Caldrons
Hand, Edward L., & Co.

Calorimeters
Palo Co.
Schaar & Co.

Calorimeters, Fuel and Gas
Gaertner, Wm., & Co.
Thomas Co., Arthur H.

Carbons, Battery
National Carbon Co.

Carbons, Resistance
National Carbon Co.

Carboy Stoppers, Acid Proof Stoneware
Knight, Maurice A.

Cars, Industrial
Easton Car & Construction Co.
Lakewood Engineering Co.

Cars, Mine and Ore
Easton Car & Construction Co.
Lakewood Engineering Co.

Cars, Tank
See Tank Cars

Cascade Basins, Acid Proof
Acid Proof Iron Products Co.
Duriron Castings Co.
Thermal Syndicate, Ltd., The.

Casseroles
Guernsey Earthenware Co.
Heroid China & Pottery Co.

Castings
Perrin, Wm. R., & Co.

Castings Acid: *Heat Resisting*
Acid Proof Iron Products Co.
Bethlehem Fdry. & Mach. Co.
Buffalo Fdry. & Mach. Co.
Duriron Castings Co.
Fulton Foundry Co.
Pratt Eng. & Machine Co.

Castings, Chemical
Acid Proof Iron Products Co.
Bethlehem Fdry. & Mach. Co.
Buffalo Fdry. & Mach. Co.
Duriron Castings Co.
Jacoby, Henry E.
Moore, Sam'l L., & Son.
Pacific Foundry Co.
Sperry, D. R., & Co.
Valley Iron Works.

Castings, Monel Metal
Supplee-Biddle Hdwe. Co.

Castings, Special & Chilled
Fulton Foundry Co.
U. S. Cast Iron Pipe & Fdy. Co.

Caustic Pots, Cast Iron
Bethlehem Fdry. & Mach. Co.
Buffalo Fdry. & Mach. Co.
Fulton Foundry Co.
U. S. Cast Iron Pipe & Fdy. Co.

Caustic Soda
Electro Chemical Company, The.
Electron Chemical Co.
Solvay Process Co.
Warner Chemical Co.
Wing & Evans, Inc.

Causticizing Apparatus
Scott, Ernest, & Co.
Zaremba Co.

Cement, Acid Proof
Anti-Hydro Waterproofing Co.
Sittig, J. W.

Centrifugal Dryers
See Dryers, Centrifugal

Centrifugal Separators
See Separators, Centrifugal

Centrifuges
Sharples Specialty Co.

Chain Screens
Codd, E. J., Co.

Chemical Apparatus
Acid Proof Iron Products Co.
Badger, E. B., & Sons Co.
Bethlehem Fdry. & Mach. Co.
Buffalo Fdry. & Mach. Co.
Devine Co., J. P.
Duriron Castings Co.
Elyria Enameled Products Co.
Hand, Edward L., & Co.
Jacoby, Henry E.
Manitowoc Engineering Works.
Moore, Sam'l L., & Son.
Pfaudler Co., The.
Pacific Foundry Co.
Pratt Eng. & Machine Co.
Roos', August, Son.
Scott, Ernest, & Co.
Stuart & Peterson Co.
Thermal Syndicate, Ltd., The.
Stevens-Alysworth Co.
U. S. Cast Iron Pipe & Fdry. Co.
Valley Iron Works. (Williamsport, Pa.)

Chemical Glassware
See Glassware, Chemical

Chemicals
Baker, J. T., Chem. Co.
Barrett Co., The.
General Chemical Co.
Marden, Orth & Hastings, Inc.
Merck & Co.
Mine & Smelter Supply Co., The.
Riverside Acid Works.
Roessler & Hasslacher Chemical Co., The.
Schaar & Co.
Solvay Process Co.
Squibb, E. R., & Sons.
Wing & Evans, Inc.

Chemists, Manufacturing
Baker, J. T., Chem. Co.
Merck & Co.
Riverside Acid Works.
Roessler & Hasslacher Chemical Co., The.
Solvay Process Co.
Squibb, E. R., & Sons.
Wing & Evans, Inc.

Chemists and Chem. Engrs.
See Professional Directory, Pages 89, 90, 91

Chlorine, Liquid
Electro Chemical Company, The.
Electron Chemical Co.
Solvay Process Co.
Warner Chemical Co.
Wing & Evans, Inc.

Chrome Brick
Harbison-Walker Refractories Co.

Clay Goods
Mine & Smelter Supply Co., The.

Coal Grinding Machinery
Aero Pulverizer Co.
Pratt Eng & Machine Co.
Raymond Bros. Impt. Pulv. Co.
Williams Patent Crusher & Pulverizer Co.

Coal Tar Pitch
Barrett Co., The.

Cocks, Acid Proof
Duriron Castings Co.
Knight, M. A.
U. S. Stoneware Co.

Coils or Worms, Acid Proof Stoneware
German-American Stoneware Wks.
Knight, Maurice A.

Combustion Boats
Engelhard, Chas.

Combustion Engineers
See Engineers, Combustion

Compressors, Air or Gas
Crowell Mfg. Co.
Nash Engineering Co.

Concentrating Tables
Mine & Smelter Supply Co., The.

Concrete Roofs
Asbestos Protected Metal Co.

Condenser Tubes
Duriorn Castings Co.

Condensers, Barmometric, Surface or Jet
Buffalo Fdry. & Mach. Co.
Connersville Blower Co.
Devine Co., J. P.
Griscom-Russell Co., The.
P. H. and F. M. Roots Company.

Construction Engineers
Moses, Pope and Messer.

Continuous Rotary Vacuum Filters
General Filtration Co.

Controllers, Temperature
Sarco Co., Inc.

Controllers, Thermostatic
See Thermostats

Converters, Rotary
General Electric Co.

Conveying Machinery
Caldwell, H. W., & Son Co.
Stephens-Adamson Mfg. Co.
Webster M'f'g. Co., The.

Conveyor Scale
Schaffer Eng. & Equip. Co.

Conveyors or Feed Worms
Acid Proof Iron Products Co.
Caldwell, H. W., & Son Co.
Duriron Castings Co.
Werner & Pfleiderer Co.

Copper, Silicon & Manganese
Electric Smelt. & Alum. Co.

Corrugated Roofing and Siding
Asbestos Protected Metal Co.

Cranes
Brown Hoisting Machinery Co.

Critical Point Determinations
Holz, Herman A.

Crucibles
Acheson Graphite Co.
Acid Proof Iron Products Co.
Bartley, Jonathan, Crucible Co.
Duriron Castings Co.
Guernsey Earthenware Co.
Mine & Smelter Supply Co., The.
Thermal Syndicate, Ltd., The.

Crushers and Grinders
Abbé Eng'g Co.
Abbé, Paul O.
Aero Pulverizer Co.
Colorado Iron Works Co.
Hardinge Conical Mill Co.
K-B Pulverizer Co.
Kent Mill Co.
Mine & Smelter Supply Co., The.
Raymond Bros. Imp. Pulv. Co.
Sturtevant Mill Co.
Williams Patent Crusher & Pulverizer Co.

Crushers, Grinders & Pulverizers
Patterson Fdry. & Mach. Co.
Pratt Eng. & Machine Co.

Crushers, Grdrs. Pulv., Lab.
Abbé Eng'g Co.
Abbé, Paul O.
Hardinge Conical Mill Co.
Sturtevant Mill Co.
Thomas Co., Arthur H.
Worthington Pump & Machy. Corp.

Crystallizing Dishes
Fry, H. C., Glass Co.
U. S. Stoneware Co.

Crystallizing Pans
Devine Co., J. P.
Knight, M. A.
U. S. Stoneware Co.

Cupola Furnaces, Foundry
Worthington Pump & Machy. Corp.

Cyanide Machinery
See Machinery, Cyanide.

Cyanide, Quicksilver Zinc Dust
Atkins, Kroll & Co.

Diaphragms
General Filtration Co., Inc.

Diffusion Batteries
Blair, Campbell & McLean, Ltd.
Lummus, The W. E., Co.
Swenson Evaporator Co.

Digesters
Elyria Enameled Products Co.
Hand, Edward L., & Co.
Koven, L. O., & Bro.
Manitowoc Engineering Works.
Pratt Eng. & Machine Co.
Stuart & Peterson Co.
Swenson Evaporator Co.
Werner & Pfleiderer Co.

Distilling Machy. Apparatus
Badger, E. B., & Sons Co.
Blair, Campbell & McLean, Ltd.
Devine Co., J. P.
Elyria Enameled Products Co.
Hand, Edward L., & Co.
Koven, L. O., & Bro.
Lummus, The W. E., Co.
Pfaudler Co., The.
Roos', August, Son.
Scott, Ernest, & Co.
Stuart & Peterson Co.
Werner & Pfleiderer Co.
Zaremba Co.

Door Screens
Codd, E. J., Co.

Drums—Steel
Detroit Range Boiler Co.

Drums—Steel Open Head
Detroit Range Boiler Co.

Dry Blast Plants
Carrier Engineering Corporation.

Dry Cell Filler
Acheson Graphite Co.

Dryers
Redfield, R. S.
Stearns-Roger Mfg. Co.

Dryers, Centrifugal
Schaum & Uhlinger, Inc.
Sharples Specialty Co.
Tolhurst Mach. Works.

Dryers, Vacuum
See Vac. Drying Apparatus

Drying Mach. & Apparatus
See also Vac. Drying Apparatus
American Process Co.
Buffalo Forge Co.
Buffalo Fdy. & Machine Co.
Devine Co., J. P.
Koven, L. O., & Bro.
Manitowoc Engineering Works.
Swenson Evaporator Co.
Werner & Pfleiderer Co.
Wheeler Condenser & Eng. Co.

Dust Collecting Engineer'g
Clark Dust Collecting Co.
Simon, Buhler & Bauman.
U. S. Blow Pipe & Dust Collecting Co.

Dust Collectors
Clark Dust Collecting Co.
Knickerbocker Co.
Raymond Bros. Imp. Pul. Co.
Simon, Buhler & Bauman.

U. S. Blow Pipe & Dust Collecting Co.
Williams Patent Crusher & Pulverizer Co.

Dust Systems
Clark Dust Collecting Co.
Pratt Eng. & Machine Co.
Simon, Buhler & Bauman.
U. S. Blow Pipe & Dust Collecting Co.

Dyes
Marden, Orth & Hastings, Inc.

Dyetubs: *See Tanks*

Dynamos, Electroplating
See Electroplating Dynamos; Supplies

Dynamos and Motors
Bogue, C. J., Elect. Co.
General Electric Co.
Jantz & Leist Elect. Co.
Westinghouse Electric & Mfg. Co.

Electric Cranes: *See Cranes*

Electric Furnace Accessories
Volta Mfg. Co., The.

Electric Furnaces
See Furnaces, Electric

Electric Furnaces, Lab'y
See Furnaces, Elec. Lab'y

Electrical Supplies
General Electric Co.

Electrical Testing Sets
American Transformer Co.
Thordarson Electric Mfg. Co.

Electrode Holders
Volta Mfg. Co., The.

Electrodes, Carbon
Acheson Graphite Co.
National Carbon Co.

Electrodes, Graphite
Acheson Graphite Co.

Electrodes, Platinum
American Platinum Works.
Baker & Co., Inc.

Electrolytic Cells
Electro Chemical Company, The.
Electron Chemical Co.
Herold China & Pottery Co.
Warner Chemical Co.

Electroplating Dynamos: Supplies
Bogue, C. J., Elect. Co.
Jantz & Leist Elect. Co.

Elevating Machinery
Caldwell, H. W., & Son Co.
Stephens-Adamson Mfg. Co.
Webster M'f'g. Co., The.

Enameled Apparatus
Elyria Enameled Apparatus Co.
Pfaudler Co., The.
Stuart & Peterson Co.

Enam. Cast Iron Apparatus Acid Proof
Sittig, J. W.

Engineers, Chemical, Consulting, Analytical, Industrial
Kalbperry Corp., The.
Moses, Pope & Messer.
Pratt Eng. & Machine Co.
Volta Mfg. Co., The.
Williams Apparatus Company.

Engineers, Consulting
See Professional Directory, Pages 89, 90, 91.

Engineers, Combustion
Improved Equipment Co.

Engineers and Contractors
Foundation Co., The.

Engineers, Furnace
Rockwell, W. S., Co.
Russell Engineering Co.

Engineers, Pyrometric
Gibb Instrument Co.
Hoiz, Herman A.

Equipment (2nd hand)
Machinery Utilities Co.
Morse Bros. Machinery & Supply Co.

Evaporators
Allbright-Nell Co., The.
Badger, E. B., & Sons, Co.
Blair, Campbell & McLean, Ltd.
Buffalo Fdy. & Mach. Co.
Devine, J. P., Co.
Griscom-Russell Co., The.
Jacoby, Henry E.
Lummus, The W. E., Co.
Pfaudler Co., The.
Pratt Eng. & Machine Co.
Redfield, R. S.
Roos', August, Son.
Scott, Ernest, & Co.
Sowers Manufacturing Co.
Swenson Evaporator Co.
Werner & Pfleiderer Co.
Wheeler Condenser & Eng. Co.
Zaremba Co.

Evaporating Dishes
Guernsey Earthenware Co.
Knight, M. A.
U. S. Stoneware Co.

Extracts
Marden, Orth & Hastings, Inc.

Extractors
Blair, Campbell & McLean Ltd.
Lummus, The W. E., Co.

Fans
Buffalo Forge Co.
Pratt Eng. & Machine Co.
Raymond Bros. Imnt. Pulv. Co.
Sturtevant Co., B. F.
Williams Patent Crusher & Pulverizer Co.

Fans, Ventilating Switchboards
General Electric Co.

Faucets, Acid Proof Stoneware
Knight, Maurice A.

Feeders
Stephens-Adamson Mfg. Co.
Webster M'f'g. Co., The.

Feed Water Heater
Griscom-Russell Co., The.

Ferro-Alloys
Goldschmidt Thermit Co.
Lavino, E. J., & Co.
Leavitt, C. W., & Co.
Titanium Alloy Mfg. Co.

Ferro-carbon—Titanium
Titanium Alloy Mfg. Co.

Filter Cloth
Huyck, F. C., & Sons.

Filter Paper
H. Reeve Angel & Co.
Laboratory Supply Co., The.

Filter, Porous Porcelain
Herold China & Pottery Co.

Filter Presses
Allbright-Nell Co., The.
Colorado Iron Works Co.
Industrial Filtration Corporation.
Jacoby, Henry E.
Johnson, John, Co.
Kelly Filter Press Co.
Koven, L. O., & Bro.
Lungwitz, E. E.
Oliver Continuous Filter Co.
Perrin, Wm. R., & Co.
Redfield, R. S.
Shriver, T., & Co.
Sperry, D. R., & Co.
Sweetland Filter Press Co.
Werner & Pfleiderer Co.

Filter Press Distil'y Grains
Swenson Evaporator Co.

Filtering Media
General Filtration Co., Inc.
Kieselguhr Co. of America.
Laclede-Christy Clay Products Co.

Filters, Water: *See Stills*

Filtros
General Filtration Co., Inc.

Fire Brick and Clay
Foote Mineral Co.
Harbison-Walker Refractories Co.
Kieselguhr Co. of America.
Laclede-Christy Clay Products Co.

Fireproof Building Materials
Asbestos Protected Metal Co.

Flasks
Fry, H. C., Glass Co.

Fluorspar
Lavino, E. J., & Co.

Foundry Supplies
Electric Smelting & Alum. Co.

Furnace Engineers
See Engineers, Furnace

Furnace Linings
Kieselguhr Co. of America.
Laclede-Christy Clay Products Co.
Quigley Furnace Specialties Co.

Furnace Linings, Graphite
Acheson Graphite Co.

Furnace, Chloridizing and Sulphating
Wedge Mechanical Furnace Co.

Furnaces
Mine & Smelter Supply Co., The.
Russell Engineering Co.

Furnaces, Cupola, Foundry
Worthington Pump & Mach. Corp.

Furnaces, Electric
Crowley, John A., Co.
Hamilton & Hansell.
Leavitt, C. W., & Co.

Furnaces, Electric, Lab'y
Brown Instrument Co.
Electric Htg. Apparatus Co.
Engelhard, Chas.
Hoskins Mfg. Co.

Furnaces, Heat Treating
Electric Htg. Apparatus Co.
Engelhard, Chas.
Hoskins Mfg. Co.
Rockwell, W. S., Co.
Russell Engineering Co.
Wedge Mechanical Furnace Co.

Furnace Hoists
Brown Hoisting Machinery Co.

Furnaces, Melting:
Oil, Gas or Powdered Coal
Rockwell, W. S., Co.

Furnaces, Muffle
Electric Htg. Apparatus Co.
Hoskins Mfg. Co.
Improved Equipment Co.
Russell Engineering Co.
Wedge Mechanical Furnace Co.

Furnaces, Roasting
Pacific Foundry Co.
Pratt Eng. & Machine Co.
Russell Engineering Co.
Wedge Mechanical Furnace Co.

Furnaces, Smelting
Colorado Iron Works Co.
Koven, L. O., & Bro.
Pacific Foundry Co.
Traylor Eng. & Mfg. Co.
Wedge Mechanical Furnace Co.

Furnaces, Sulphur
Pacific Foundry Co.
Pratt Eng. & Machine Co.
Wedge Mechanical Furnace Co.

Gas Filters
Simon, Buhler & Bauman.

Gas Producers
Improved Equipment Co.
Morgan Const. Co.
Smith Gas Engineering Co., The.

Gas Pumps and Exhausters
See Pumps, Gas, Liquid, Vacuum

Gas Washers
Simon, Buhler & Bauman.

Gauges, Recording, Indicating, Draft, Pressure
Bristol Co., The.
Taylor Instrument Co.
Thwing Instrument Co.

Gears
Caldwell, H. W., & Son Co.
Pratt Eng. & Machine Co.

Gears, Silent
General Electric Co.

Generators (Wood)
Eagle Tank Co.

Generators:
See Dynamos and Motors

Glass Blowing
Palo Co.

Glassware
Mine & Smelter Supply Co., The.

Glassware, Chemical
Eberbach & Son, Co., Inc.
Griebel Instrument Co.
Laboratory Supply Co., The.

Glazing Construction
Asbestos Protected Metal Co.

Graphite
Acheson Graphite Co.

Grinders
See Crushers and Grinders

Hardness Testers
Hoiz, Herman A.

Heaters, Feed Water
Griscom-Russell Co.
Webster & Co., Warren.

Heating Apparatus
Buffalo Forge Co.

Heating Systems
Webster & Co., Warren.

High Speed Steel
Standard Alloys Co.

Hoists
Brown Hoisting Machinery Co.

Hydro Extractors
Schaum & Uhlinger, Inc.
Sharples Specialty Co.
Tolhurst Mach. Wks.

Hydrometers
Griebel Instrument Co.

Hydrometer Jars
Fry, H. C., Glass Co.

Hydrogen Plants
Improved Equipment Co.

Instruments, Electrical and Testing
Bristol Co., The.
General Electric Co.
Hoskins Mfg. Co.
Leeds & Northrup Co., The.
Shore Instrument Co.
Stupakoff Laboratories.
Taylor Instrument Co.
Thwing Instrument Co.
Westinghouse Electric & Mfg. Co.

Insulating Material, Heat
Kieselguhr Co. of America.

Intermediates
Marden, Orth & Hastings, Inc.

Iron and Steel, Corrugated
Asbestos Protected Metal Co.

Jars, Acid Storage
U. S. Stoneware Co.

Jets and Nozzles, Acid Proof Stoneware
Duriron Castings Co.
Knight, M. A.

Joints
Goldschmidt Thermit Co.

Kettles, Acid Proof
Acid Proof Iron Products Co.
Duriron Castings Co.
Fulton Foundry Co.
Pfaudler Co., The.
Pratt Eng. & Machine Co.

Kettles, Acid Proof Stoneware
German-American Stoneware Wks.
Knight, Maurice A.

Kettles, Cast Iron
Buffalo Fdy. & Machine Co.
Koven, L. O., & Bro.
Sowers Manufacturing Co.
Stevens-Aylsworth Company.
U. S. Cast Iron Pipe & Fdy. Co.
Werner & Pfleiderer Co.

Kettles, Steam-Jacketed
Buffalo Fdy. & Machine Co.
Day, The J. H., Co.
Detroit Heating & Lighting Co.
Devine Co., J. P.
Elyria Enameled Products Co.
Hand, Edward L., & Co.
Pfaudler Company, The.
Stevens-Aylsworth Co.
Stuart & Peterson Co.
Werner & Pfleiderer Co.

Kettles, Stoneware
U. S. Stoneware Co.

Kiln, Lime
Improved Equipment Co.

Kiln, Rotary & Nodulising
American Process Co.

Laboratory Apparatus and Supplies
Mine & Smelter Supply Co., The.
Schaar & Co.

Laboratory Supplies
Daigger, A., & Co.
Gaertner, Wm., & Co.
Guernsey Earthenware Co.
Hoskins Mfg. Co.
Laboratory Supply Co., The.
Leeds & Northrup.
Palo Co.
Thermal Syndicate Ltd., The.
Thomas Co., Arthur H.

Lamp, Arc & Incandescent
General Electric Co.

Lead-lined Tanks
Eagle Tank Co.

Lifts, Air Jet
Bethlehem Fdy. & Mach. Co.

Locomotives
General Electric Co.

Machinery, Agitating
Day, The J. H., Co.
Dorr Co., The.
Werner & Pfleiderer Co.

Machinery, Classifying
Dorr Co., The.

Machinery, Concentrating
Colorado Iron Works Co.
Dorr Co., The.
Kent Mill Co.
Mine and Smelter Supply Company.
Swenson Evaporator Co.
Worthington Pump & Machy. Corp.

Machinery, Conveying & Elevating
Caldwell, H. W., & Son Co.
Stephens-Adamson Mfg. Co.
Webster M'f'g. Co., The.

Machinery, Cyanide
Colorado Iron Works Co.
Dorr Co., The.
Worthington Pump & Machy. Corp.

Machinery, Electrical
General Electric Co.

Machinery, Elevating or Conveying
Caldwell, H. W., & Son Co.

Machinery, Metallurgical and Mining
Abbé Eng'g Co.
Abbé, Paul O.
Aero Pulverizer Co.
American Process Co.
Colorado Iron Works Co.
Dorr Co., The.
Dwight & Lloyd Sintering Co.
General Filtration Co., Inc.
Hardinge Conical Mill Co.
Kelly Filter Press Co.
K-B Pulverizer Co.
Kent Mill Co.
Lungwitz, E. E.
Mine and Smelter Supply Company, The.
Morse Bros. Machinery & Supply Co.
Pacific Foundry Co.
Raymond Bros. Imp. Pulv. Co.
Stearns-Roger Mfg. Co.
Sturtevant Mill Co.
Sweetland Filter Press Co., Inc.
Wedge Mechanical Furnace Co.
Worthington Pump & Machy. Corp.

Machinery, Mixing and Kneading
Abbé Eng'g Co.
Abbé, Paul O.
Buffalo Fdy. & Machy. Co.
Day, J. H., Co.
Dunning, W. D.
Koven, L. O., & Bro.
Sowers Manufacturing Co.
Werner & Pfleiderer Co.
Worthington Pump & Machy. Corp.

Machinery, Ore
Brown Hoisting Machinery Co.

Machinery, Pulverizing
Abbé Eng'g Co.
Abbé, Paul O.
Aero Pulverizer Co.
Day, J. H., Co.
Dunning, W. D.
Hardinge Conical Mill Co.
K-B Pulverizer Co.
Kent Mill Co.
Mead & Co.
Pratt Eng. & Machine Co.
Raymond Bros. Imp. Pulv. Co.
Sturtevant Mill Co.
Williams Patent Crusher & Pulverizer Co.
Worthington Pump & Machy. Corp.

Machinery, Soap
Dunning, W. D.

Machinery, Special
Allbright-Nell Co., The.
Buffalo Fdy. & Machine Co.
Day, The J. H., Co.
Fulton Foundry Co.
Stevens-Aylsworth Co.
Volta Mfg. Co., The.
Werner & Pfleiderer Co.

Machinery, Thickening and Dewatering
Dorr Co., The.
Werner & Pfleiderer Co.

Machinery, Wood Pulp
Swenson Evaporator Co.

Magnesite
Foote Mineral Co.
Harbison-Walker Refractories Co.
Levensaler-Spier Corp.

Magnesium Metal
Aviation Materials Corp'n.
Leavitt, C. W., & Co.
Norton Laboratories, Inc.

Metallographic Apparatus
Hoiz, Herman A.
Palo Co.

Metallo-Radiographic
Hoiz, Herman A.

Metallurgical Engineers
See Professional Directory, Pages 89, 90, 91.

Metallurgical Processes
Dorr Co., The.
Dwight & Lloyd Sintering Co.

Metal, Asbestos Protected
Asbestos Protected Metal Co.

Metals
Electrolytic Zinc Co., Inc.
Goldschmidt Thermit Co.
Lavino, E. J., & Co.
Leavitt, C. W., & Co.
Metals Disintegrating Co., Inc.

Meters, Flow, Air, Gas, Water
General Electric Co.
Spray Engineering Co.

Microscopes
Palo Co.
Thomas Co., Arthur H.

Mills, Ball, Pebble and Tube
Abbé Eng'g Co.
Abbé, Paul O.
Colorado Iron Works Co.
Hardinge Conical Mill Co.
Mine & Smelter Supply Co., The.
Sittig, J. W.

Mills, Conical
Hardinge Conical Mill Co.

Mills, Emery
Sturtevant Mill Co.

Minerals
Foote Mineral Co.

Mixers, Acidulating
Pratt Eng. & Machine Co.

Mixers, Batch
Pratt Eng. & Machine Co.

Mixing Tanks
Pfaudler Company, The.

Molybdenum Ore
Foote Mineral Co.

Molybdenum Wire
Hoiz, Herman A.

Monel Metal
Supplee-Biddle Hdwe. Co.
Montejus, Automatic
Bethlehem Fdy. & Mach. Co.
Buffalo Fdy. & Mach. Co.
Mortars and Pestles
U. S. Stoneware Co.
Motors, Electric
General Electric Co.
Muffles
Mine & Smelter Supply Co., The.
Russell Engineering Co.
Multiple Effect Distlg. App.
Devine Co., J. P.
Swenson Evaporator Co.
Nozzle, Spray
Buffalo Forge Co.
Oil Burners
Mine & Smelter Supply Co., The.
Ores: *See Rare Minerals and Ores.*
Ore and Coal Handling Machinery
Brown Hoisting Machinery Co.
Webster M'f'g. Co., The.
Oxide, Gas Purifying
Lavino, E. J., & Co.
Oxygen Cylinders
Janney, Steinmetz & Co.
Paint Pigment, Graphite
Acheson Graphite Co.
Paints, Acid Proof & Technical
Toch Brothers.
Pans, Crystallizing
Pfaudler Company, The.
Paste Pyro
Nehls, Carl, Alloy Co.
Patent Attorneys
See Professional Directory, Pages 89, 90, 91.
Pebbles, Flint
Atkins, Kroll & Co.
Pebble Mills
See Mills, Ball, Pebble and Tube
Petri Dishes
Fry, H. C., Glass Co.
Pipe, Acid
U. S. Stoneware Co.
Pipe, Cast Iron
U. S. Cast Iron Pipe & Fdy. Co.
Pipe & Fittings, Acid Proof
Acid Proof Iron Products Co.
Chadwick-Boston Lead Co., The.
Duriron Castings Co.
Elyria Enameled Products Co.
Roos', August, Son.
Stuart & Peterson Co.
Thermal Syndicate, Ltd., The.
U. S. Stoneware Co.
Wyckoff, A., & Son Co.
Pipe & Fittings, Acid Proof Stoneware
German-American Stoneware Wks.
Knight, Maurice A.
Pipe & Fittings, Lead, Tin or Silver Lined
Badger, E. B., & Sons Co.
Chadwick-Boston Lead Co., The.
Pitch, Coal Tar
Barrett Co., The.
Platinum
American Platinum Works.
Baker & Co., Inc.
Palo Co.
Thomas Co., Arthur H.
Platinum Thermocouples
Holz, Herman A.
Plug Cocks: *See Cocks, Acid Proof*
Porcelain Ware
Guernsey Earthenware Co.
Heroid China & Pottery Co.
Laboratory Supply Co., The.
Sittig, J. W.
Pots, Acid Proof
Acid Proof Iron Products Co.
Duriron Castings Co.
Fulton Foundry Co.
Moore, Sam'l L., & Son.
U. S. Stoneware Co.
Werner & Pfleiderer Co.
Pots, Acid Proof Stoneware
Knight, Maurice A.
Pulmotor
Draeger Oxygen Apparatus Co.
Pulverizers
Mine & Smelter Supply Co., The.
Pulverizers, Laboratory
See Crushers, Grinders, Pulverizers, Laboratory
Pulverizing Machinery
See Machinery, Pulverizing
Pumps, Acid or Acid Gases
Abbé Eng. Co.
Duriron Castings Co.
Elmore, G. H.
Nash Engineering Co.
Pratt Eng. & Machine Co.
Sittig, J. W.
U. S. Stoneware Co.
Pumps, Centrifugal
Abbé Eng. Co.
Duriron Castings Co.
Elmore, G. H.
Pelton Water Wheel Co.
Pumps, Gas, Liq. or Vacuum
Abbé Eng. Co.
Buffalo Fdy. & Mach. Co.
Connersville Blower Co.
Nash Engineering Co., The.
Pratt Eng. & Machine Co.
P. H. and F. M. Roots Company.
Sittig, J. W.
Pumps, Rotary, Oil or Water
Abbé Eng. Co.
Connersville Blower Co.
Pelton Water Wheel Co.
P. H. and F. M. Roots Company.
Pumps, Vacuum
Devine Co., J. P.
Pyrites
Lavino, E. J., & Co.
Pyrometers
Bristol Co., The.
Engelhard, Chas.
Gibb Instrument Co.
Holz, Herman A.
Hoskins Mfg. Co.
Leeds & Northrup Co., The.
Nehls, Carl, Alloy Co.
Palo Co.
Shore Instrument Co.
Stupakoff Laboratories.
Taylor Instrument Co.
Thomas Co., Arthur H.
Thwing Instrument Co.
Uehling Instrument Co.
Pyrometer Installations
Gibb Instrument Co.
Holz, Herman A.
Pyrometer Paste
Nehls, Carl, Alloy Co.
Pyrometer Protection Tubes
Engelhard, Chas.
Heroid China & Pottery Co.
Thermal Syndicate, Ltd., The.
Pyrometer Sheets, Graphite
Acheson Graphite Co.
Pyroscope
Shore Instrument Co.
Quartz Glass
Engelhard, Chas.
Railways, Industrial & Portable
Easton Car & Construction Co.
Lakewood Engineering Co.
Rare Minerals and Ores
Atkins, Kroll & Co.
Foote Mineral Co.
Jefferson Tungsten Co.
Lavino, E. J., & Co.
Leavitt, C. W., & Co.
Vanadium-Alloys Steel Co.
Recalescence Outfits
Holz, Herman A.
Receivers or Woulff Bottles —Acid Proof Stoneware
German-American Stoneware Wks.
Knight, Maurice A.
Recorders, CO,
Sarco Company, Inc.
Uehling Instrument Co.
Recording Instruments, Pressure, Temperature, Electricity, Motion, Speed, Time
Bristol Co., The.
Engelhard, Chas.
Holz, Herman A.
Hoskins Mfg. Co.
Leeds & Northrup Co., The.
Pyroelectric Instrument Co.
Taylor Instrument Co.
Thwing Instrument Co.
Uehling Instrument Co.
Refractories
Foote Mineral Co.
Kieselguhr Co. of America.
Laclede-Christy Clay Products Co.
Regulators, Automatic Humidity
Carrier Engineering Corp.
Regulators, Pressure
Connersville Blower Co.
P. H. and F. M. Roots Company.
Regulators, Temperature
See Temperature Controllers
Regulators, Water Temperature
Sarco Company, Inc.
Resistance Wire
See Wire, Resistance
Resistant Chemical Glassware
Fry, H. C., Glass Co.
Resuscitation Devices
Draeger Oxygen Apparatus Co.
Retorts
Bartley, Jonathan, Cruc. Co.
Buffalo Fdy. & Machine Co.
Retorts, Acid
Buffalo Fdy. & Mach. Co.
Fulton Foundry Co.
Roofings—Fume Proof
Asbestos Protected Metal Co.
Brown Hoisting Machinery Co.
Rotary Converters
Westinghouse Electric & Mfg. Co.
Rotary Vacuum Filters
General Filtration Co., Inc.
Rutile
American Rutile Co.
Scales, Weighing
Werner & Pfleiderer Co.
Scleroscope
Holz, Herman A.
Shore Instrument Co.
Screen Doors
Codd, E. J., Company.
Screening Machinery
Stephens-Adamson Mfg. Co.
Webster M'f'g. Co., The.
Worthington Pump & Mach. Corp.
Screens
Colorado Iron Works Co.
Kent Mill Co.
Sturtevant Mill Co.
Worthington Pump & Machy. Corp.
Scrubbers, Gas
Buffalo Forge Co.
Seamless Steel Tanks
Janney, Steinmetz & Co.
Separators, Air
Aero Pulverizer Co.
Pratt Eng. & Machine Co.
Raymond Bros. Imp. Pulv. Co.
Williams Patent Crusher & Pulverizer Co.
Separators, Centrifugal
Schaum & Uhlinger, Inc.
Sharpless Specialty Co.
Tolhurst Mach. Wks.
Separators, Steam and Oil
Griscom-Russell Co., The.
Webster & Co., Warren.
Silica Brick
Harbison-Walker Refractories Co.
Laclede-Christy Clay Products Co.
Silica, Fused
Thermal Syndicate, Ltd., The.
Silver Piping
Wall, A. T., Co.
Silver Rod
Wall, A. T., Co.
Silver Sheet
Wall, A. T., Co.
Sintering Processes
Dwight & Lloyd Sintering Co.
Spray Nozzles: *See Nozzles, Spray*
Steel, Chrome-Nickel
Crowley, John A., Co.
Steel, Chrome-Vanadium
Crowley, John A., Co.
Steel, Electric
Crowley, John A., Co.
Steel, Spring
Crowley, John A., Co.
Steel Mixing Bowls
Janney, Steinmetz & Co.
Steel Pots & Pans
Janney, Steinmetz & Co.
Steel Sheets: *See Sheets, Steel*
Stills
Badger, E. B., & Sons Co.
Blair, Campbell & McLean, Ltd.
Detroit Heating & Lighting Co.
Devine Co., J. P.
Fulton Foundry Co.
Griscom-Russell Co., The.
Lummus, The W. E., Co.
Roos', August, Son.
Stevens-Alyaworth Company.
Thomas Co., Arthur H.
Werner & Pfleiderer Co.
Zaremba Co.
Stirrers
Acheson Graphite Co.
Acid Proof Iron Products Co.
Duriron Castings Co.
Werner & Pfleiderer Co.
Stokers
Laclede-Christy Clay Products Co.
Stoneware, Acid Proof Chemical
German-American Stoneware Wks
Knight, Maurice A.
Stoneware, Chemical
Sittig, J. W.
U. S. Stoneware Co.
Stoppers
Bartley, Jonathan, Crucible Co.
Stoppers, Carboy
U. S. Stoneware Co.
Suction Filters, Acid Stoneware
German-American Stoneware Wks
Knight, Maurice A.
Sulphur Burners
Carthage Machine Company.
Glens Falls Machine Works.
Pratt Eng. & Machine Co.
Valley Iron Works, (Appleton, Wis.)
Sulphur, Crude
Union Sulphur Co., The.
Sulphur Dioxide, Liquid
Ansul Chemical Co.
Sulphuric Acid Plants
Kalbperry Corp., The.
Switchboards
Westinghouse Electric & Mfg. Co.
Syphons, Acid
Knight, M. A.
U. S. Stoneware Co.
Tanks, Acid
Chadwick-Boston Lead Co., The.
Elyria Enameled Products Co.
Pfaudler Co., The.
Stuart & Peterson Co.
U. S. Stoneware Co.
Tanks, Acid Proof Stoneware
German-American Stoneware Wks.
Knight, Maurice A.
Tanks—Air
Detroit Range Boiler Co.
Tanks, Electrolytic
U. S. Stoneware Co.
Tanks, Steel
Hamburg Boiler Works.
Manitowoc Engineering Works.
Stevens-Alyaworth Co.
Stevens Brothers.
Tanks, Storage
Blair, Campbell & McLean, Ltd.
Chadwick-Boston Lead Co., The.
Corcoran, A. J., Inc.
Detroit Heating & Lighting Co.
Detroit Range Boiler Co.
Eagle Tank Co.
Hauser-Stander Tank Co., The.
Kalamazoo Tank & Silo Co.
Koven, L. O., & Bro.
Lummus, The W. E., Co.
Pfaudler Co., The.
Stevens-Alyaworth Co.
U. S. Stoneware Co.
Tanks, Welded
Kellogg, The, M. W. Co.
Tanks, Wood
Corcoran, A. J., Inc.
Eagle Tank Co.
Hauser-Stander Tank Co., The.
Kalamazoo Tank & Silo Co.
U. S. Wind Engine & Pump Co.
Testing Laboratories
See Professional Directory, Pages 89, 90, 91.
Testing Machines, Metal
Holz, Herman A.
Shore Instrument Co.
Thermit
Goldschmidt Thermit Co.
Thermometers
Bristol Co., The.
Engelhard, Chas.
Griebel Instrument Co.
Leeds & Northrup Co., The.
Palo Co.
Taylor Instrument Co.
Thwing Instrument Co.
Thermostats
Sarco Company, Inc.
Tile, Tower Grillage, Acid Proof Stoneware
Knight, M. A.
Titanium
Goldschmidt Thermit Co.
Titanium Ores
American Rutile Co.
Foote Mineral Co.
Titanium Alloy Mfg. Co.
Tool Steel
Standard Alloys Co.
Towers, Acid Proof
Acid Proof Iron Products Co.
Duriron Castings Co.
Thermal Syndicate, Ltd., The.
U. S. Stoneware Co.
Towers, Acid Proof Stoneware
German-American Stoneware Wks.
Knight, Maurice A.
Tracks, Industrial and Portable
Easton Car & Construction Co.
Lakewood Engineering Co.
Transformers
American Transformer Co.
General Electric Co.
Thordarson Electric Mfg. Co.
Westinghouse Electric & Mfg. Co.
Transmission Machinery
Stephens-Adamson Mfg. Co.
Webster M'f'g. Co., The.
Traps, Steam
Sarco Company, Inc.
Trolleys, I Beam
Brown Hoisting Machinery Co.
Tube Mills
See Mills, Ball, Pebble, Tube
Tungsten Arc Lamps
Holz, Herman A.
Tungsten Ores
Jefferson Tungsten Co.
Vanadium-Alloys Steel Co.
Turntables, Industrial Railway
Easton Car & Construction Co.
Lakewood Engineering Co.
Uranium Alloys
Standard Alloys Co.
Vacuum Dryers
Devine Co., J. P.
Vacuum Drying Apparatus
Buffalo Fdy. & Mach. Co.
Devine, J. P.
Jacoby, Hy. E.
Pratt Eng. & Machine Co.
Scott, Ernest, & Co.
Sowers Manufacturing Co.
Werner & Pfleiderer Co.
Vacuum Filters
General Filtration Co., Inc.
Knight, M. A.
Stevens-Alyaworth Co.
Vacuum Pans
Badger, E. B., & Sons Co.
Blair, Campbell & McLean, Ltd.
Buffalo Fdy. & Mach. Co.
Detroit Heating & Lighting Co.
Devine, J. P., Co.
Lummus, The W. E., Co.
Pfaudler Company, The.
Pratt Eng. & Machine Co.
Roos', August, Son.
Sowers Manufacturing Co.
Swenson Evaporator Co.
Werner & Pfleiderer Co.
Zaremba Co.
Vacuum Pumps
Abbé Eng. Co.
Crowell Mfg. Co.
Devine Co., J. P.
Nash Engineering Co.
Roots, P. H., & F. M. Co.
Valves, Acid-Proof
Acid Proof Iron Products Co.
Duriron Castings Co.
Pratt Eng. & Machine Co.
U. S. Stoneware Co.
Valves, Vacuum
Sarco Company, Inc.
Valves or Cocks, Acid Proof Stoneware
Knight, Maurice A.
Vanadium Alloys
Standard Alloys Co.
Vats, Acid-Proof
Acid Proof Iron Products Co.
Duriron Castings Co.
U. S. Stoneware Co.
Vats, Wood
Eagle Tank Co.
Water Tanks and Towers
Eagle Tank Co.
Water Wheels
Pelton Water Wheel Co.
Waugh Glazing Construction
Asbestos Protected Metal Company.
Weighing Machines
Schaffer Eng. & Equipment Co.
Sturtevant Mill Co.
Werner & Pfleiderer Co.
Welded Tanks
Kellogg, The M. W., Co.
Welding Materials
Acheson Graphite Co.
General Electric Co.
Goldschmidt Thermit Co.
National Carbon Co.
Welding Outfits, Arc
General Electric Co.
Welding, Thermit Process
Goldschmidt Thermit Co.
Winches, Electric
Volta Mfg. Co., The.
Wire, Resistance
Driver, Harris Wire Co.
Wood Pipe
Wyckoff, A., & Son Co.
Wood Distillation
Badger, E. B., & Sons Co.
Blair, Campbell & McLean, Ltd.
Devine Co., J. P.
Lummus, The W. E., Co.
Manitowoc Engineering Works.
Moses, Pope and Messer.
Zaremba Co.
Wood Tanks
Corcoran, A. J., Inc.
Eagle Tank Co.
Hauser-Stander Tank Co., The.
Kalamazoo Tank & Silo Co.
U. S. Wind Engine & Pump Co.
Wood Vats
Eagle Tank Co.
Zinc
Metals Disintegrating Co., Inc.

ALPHABETICAL INDEX TO ADVERTISEMENTS

A

Abbe Engineering Co. 55
Abbe, Paul O. 101
Acheson Graphite Co. 35
Acid Proof Iron Products Company, The 20
Aero Pulverizer Co. 52
Ainsworth, Wm., & Sons 82
Allbright-Nell Co., The 67
American Platinum Works 79
American Process Co. 2
American Rutile Co. 48
American Transformer Co., The 46
Angel, H. Reeve & Co., Inc. 85
Ansul Chemical Co. 45
Anti-Hydro Waterproofing Co. 62
Asbestos Protected Metal Co. 78
Atkins, Kroll & Co. 48
Aviation Materials Corp. 48

B

Badger, E. B., & Sons Co. 8, 9, 10, 11
Baker, J. T., Chemical Co. 44
Baker & Co., Inc. 96
Barrett Co., The 38
Bartley, Jonathan, Crucible Co. 42
Bethlehem Foundry & Machine Co. 23
Blair, Campbell & McLean, Ltd. 64
Bogue Elec. Co., C. J. 46
Bristol Co., The 102
Brown Hoisting Mach. Co., The 40
Brown Instrument Co., The 84
Buffalo Forge Co. 61
Buffalo Fdry. & Mach. Co. 12, 13, 14

C

Caldwell, H. W., & Son Co. 52
Carrier Engineering Corporation 60
Carthage Machine Co. 48
Chadwick-Boston Lead Co. 62
Clark Dust Collecting Co. 60
Codd, E. J., Company 50
Colorado Iron Works 67
Connersville Blower Co. 52
Corcoran, A. J., Inc. 74
Crowley, John A., Co. 7
Crowell Mfg. Co. 60

D

Daigger, A., & Co. 76
Day, J. H., Co. 51
Detroit Heating & Lighting Co. 68
Detroit Range Boiler Company 31
Devine, J. P., Co. 17
Dorr Co., The 57
Draeger Oxygen Apparatus Co. 66
Driver-Harris Wire Co. 102
Dunning, W. D. 57
Duriron Castings Co. 19
Dwight & Lloyd Sintering Co. 50

E

Eagle Tank Co. 74
Easton Car & Construction Co. 75
Eberbach & Son Co., Inc. 76
Electric Heating Apparatus Co. 78
Electric Smelting & Aluminum Co. 48
Electro Chemical Co., The 51
Electron Chemical Co. 29
Elmore, G. H. 58
Elyria Enameled Products Co., The 72
Engineers Society of Western Pennsylvania 50
Englehard, Charles 85

F

Foote Mineral Co., Inc. 49
For Sale and Want Ads. 92, 93, 94
Foundation Co. 37
Fry, H. C., Glass Co. 79
Fulton Foundry Company 56

G

Gaertner, William, & Co. 86
General Electric Co. 41
General Filtration Co., Inc. 66
German-American Stoneware Wks. 75
Gibb Instrument Co. 33
Glens Falls Machine Works 5
Goldschmidt Thermit Co. 2
Griebel Instrument Co. 77
Griscom-Russell Co., The 66
Guernsey Earthenware Co. 76

H

Hamburg Boiler Works 78
Hamilton & Hansell 47
Hand, E. L., & Co. 73
Harbison-Walker Refractories Co. 45
Hardinge Conical Mill Co. 55
Hauser-Stander Tank Co., The 68
Hercules Engineering Corp. 91
Herold China & Pottery Co. 39
Holz, Herman A. 84
Hoskins Mfg. Co., The 80
Huyck, F. C., & Sons 66

I

Improved Equipment Co., The 58
Industrial Filtration Corporation 26

J

Jacoby, Henry E. 66
Janney-Steinmetz Co. 72
Jantz & Leist Elec. Co. 46
Jefferson Tungsten Co. 48
Johnson, John, Co. 66

K

Kalamazoo Tank & Silo Co. 74
Kalbperry Corp., The 59
K-B Pulverizer Co. 54
Kellogg, The M. W. Co. 73
Kelly Filter Press Co. 27
Kent Mill Co. 52
Kieselguhr Co. of America 51
Knickerbocker Co., The 61
Knight, M. A. 76
Koven, L. O., & Bro. 73

L

Laboratory Supply Co., The 76
Laclede-Christy Clay Products Co. 45
Lakewood Engineering Co. 30
Lavino, E. J., & Co. 48
Leavitt, C. W., & Co. 47
Leeds & Northrup Co., The 84
Levensaler-Spier Corporation 48
Little, Arthur D., Inc. 24
Lummus, The Walter E. Company 15
Lungwitz, Emil E. 27

M

McGraw-Hill Book Co. 87
Machinery Utilities Co. 92
Manitowoc Engineering Works 66
Marchant Calculating Machine Co. 82
Marden, Orth & Hastings, Inc. 38
Mead & Co. 54
Merck & Co. 86
Metals Disintegrating Co., Inc. 48
Miller Smelting & Refining Co. 92
Milton Brick Co. 45
Mine & Smelter Supply Co., The 83
Moore, Samuel L., & Son 59
Morgan Construction Co. 52
Morse Bros. Machinery & Supply Co. 92
Moses, Pope & Messer, Inc. 58

N

Nash Engineering Co. 65
National Carbon Co. 47
Nehls, Carl, Alloy Co. 86
Norton Laboratories, Inc., The 49

O

Oliver Continuous Filter Co. 25

P

Pacific Foundry Co. 21
Palo Company 76
Pelton Water Wheel Co. 56
Perrin, William R., & Co. 67
Pfaudler Co., The 70
Power & Mining Machinery Co. 43
Pratt Engineering & Machine Co. 18
Professional Directory. 89, 90, 91
Publishers' Pages 36, 88
Pyrolectric Instrument Co. 86

Q

Quigley Furnace Specialties Co. 45

R

Raymond Bros. Impact Pulverizer Co. 1
Redfield, Robert S. 68
Riverside Acid Works 44
Rockwell, W. S., Co. 46
Roessler & Hasslacher Chemical Co., The 39
Roos', August, Son 4
Roots, P. H. & F. M., Co. 65
Russell Engineering Co. 52

S

Sarco Co., Inc. 81
Schaar & Co. 76
Schaffer Eng'g & Eq'pt Co. 58
Schaum & Uhlinger, Inc. 86
Scott, Ernest, & Co. 68
Searchlight Section. 92, 93, 94
Sharples Specialty Co., The 58
Shore Instrument & Mfg. Co. 82
Shriver, T., & Co. 2
Simon Buhler & Baumann, Inc. 58
Sittig, J. W. 74
Smith Gas Engineering Co., The 52
Solvay Process Co. 44
Sowers Mfg. Co. 69
Sperry, D. R., & Co. 72
Spray Engineering Co. 63
Squibb, E. R., & Sons 90
Standard Alloys Co. 49
Stearns-Roger Mfg. Co. 51
Stephens-Adamson Mfg. Co. 53
Stevens-Aylsworth Co. 50
Stevens Brothers 71
Stuart & Peterson Co., The 71
Stupakoff Laboratories, The 83
Sturtevant Co., B. F. 60
Sturtevant Mill Co. 6
Supplee-Biddle Hardware Co. 70
Sweetland Filter Press Co., Inc., The 67
Swenson Evaporator Co. 69

T

Taylor Instrument Companies 80
Thermal Syndicate, Ltd., The 77
Thomas, Arthur H., Co. 77
Thordarson Electric Mfg. Co. 46
Thwing Instrument Co. 85
Titanium Alloy Mfg. Co. 48
Toch Brothers 63
Tolhurst Machine Works 64
Traylor Eng. & Mfg. Co. 53

U

Uehling Instrument Co. 82
Union Carbide Co. 48
U. S. Blow Pipe & Dust Collecting Co. 58
U. S. Cast Iron Pipe & Fdry. Co. 22
U. S. Stoneware Co. 74
U. S. Wind Engine & Pump Co. 74
Union Sulphur Co. 44

V

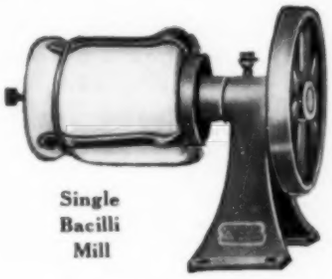
Valley Iron Works (Appleton, Wis.) 53
Valley Iron Works, (Williamsport, Pa.) 56
Vanadium-Alloys Steel Co., The 51
Volta Mfg. Co. 46

W

Wall, A. T., Co. 78
Warner Chemical Co. 28
Webster Mfg. Co., The 53
Webster Warren & Co. 59
Wedge Mechanical Furnace Co. 32
Werner & Pfleiderer Co. 81
Westinghouse Electric & Mfg. Co. 34
Wheeler Condenser & Eng. Co. 68
Williams Apparatus Co. 78
Williams Patent Crusher & Pulv. Co. 54
Wing & Evans, Inc. 44
Worthington Pump & Machinery Corp. 43
Wyckoff, A., & Sons Co. 62

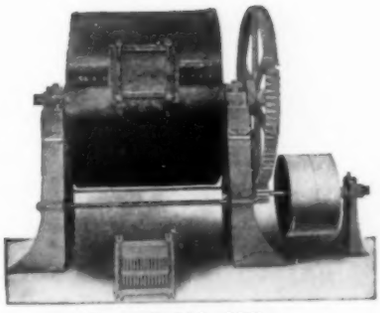
Z

Zaremba Co. 16



Single Bacilli Mill

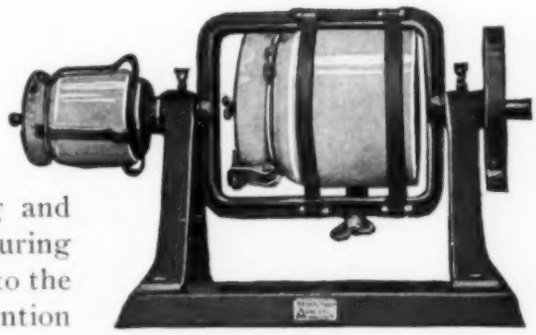
Paul O. Abbé Jar and Pebble Mills



No. 3 Pebble Mill

will rapidly grind either dry or wet materials to a UNIFORM product

Next in importance to the fineness or smoothness of ground or mixed material comes the speed and ease with which it may be produced in large quantities.

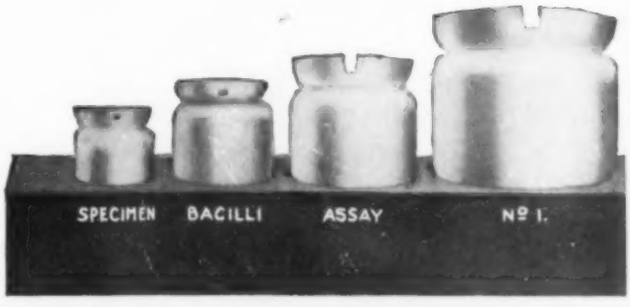


Single Assay Mill with Specimen Jar

The doubling, trebling and quadrupling of my sales during the past few years points to the fact that my personal attention in solving the mixing and disintegration problems of my customers has been appreciated.

I will always welcome the opportunity to extend my personal services in aiding to refine your product, speed up your output or reduce your costs.

Three Catalogs, A, B and C, show the entire Paul O. Abbé line. Send for description and quotation on machinery in which you are interested.



Jars for Ball Mills

PAUL O. ABBÉ

CRUSHING, CUTTING, GRINDING, MIXING, PULVERIZING AND SIFTING MACHINERY

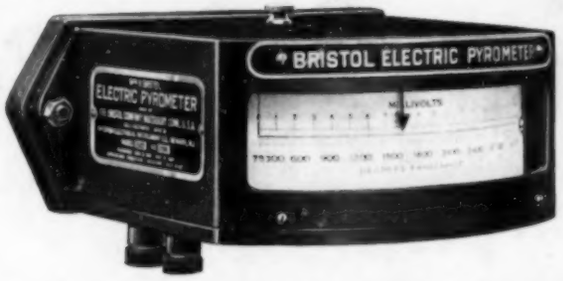
SEMPER OPUS OPTIMUM PEBBLE MILL ABBÉ

Dufour Bolting Cloth

Rooms 920-924 Johnson Bldg., New York

SEMPER OPUS OPTIMUM PEBBLE MILL ABBÉ

A FEW ADVANTAGES OF THE FAMOUS WESTON MOVEMENT FOUND IN ALL



BRISTOL'S ELECTRIC PYROMETERS

Weston New Pivot Jewel High Resistance Millivoltmeter Movements have a high degree of accuracy and are exceedingly sensitive. The slightest change in temperature of the fire end with its corresponding change in E.M.F. is immediately shown by the instrument.

Weston Movements are absolutely dead beat. When the fire end increases or decreases in temperature suddenly, the instrument will show the variation exactly as it takes place. The pointer will not swing higher or lower than necessary to indicate the actual change in temperature. The movement is properly damped so that the pointer will come to rest immediately.

They are durable. The Weston movements that were put in pyrometers ten years ago are giving the same high quality of service today.

Write For Bulletin 205-B

Let us give you the full story. Write for particulars.
You're sure of getting the best if you get Bristol's.

THE BRISTOL CO., Waterbury, Conn., U.S.A.

BRANCH OFFICES:

Old South Bldg. Boston | 114 Liberty Street New York | Frick Bldg., Annex Pittsburgh | Monadnock Bldg. Chicago | Rialto Bldg. San Francisco

WE

are quite proud of Nichrome Carburizing Boxes.

—if we weren't we wouldn't paste this label containing our name and address on every casting.

YOU

and by "you" we mean users of Nichrome castings (which have strength, non-warping characteristics and resistance to oxidation at high temperatures).

—you must be proud of the economy that Nichrome Carburizing Boxes give you in metal treating.

—if you weren't we wouldn't be building the present addition to our plant.

DRIVER-HARRIS WIRE CO.

CHICAGO 28 So. JEFFERSON ST. HARRISON, N.J. MANCHESTER ENGLAND